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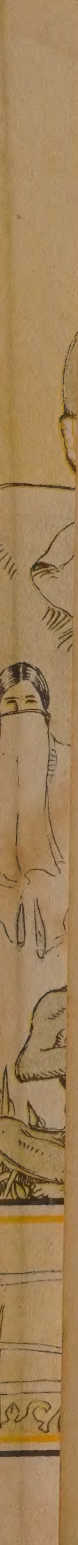

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IX. The Child in the Home
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XI. Home and School Guide—Index

THE NEW
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A Library of Knowledge

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EDITOR'S FOREWORD

THOSE responsible for the selection of reading matter for boys and girls, whether in the home, the school or the library, find themselves confronted with a bewildering array of material. Accordingly, the editors of THE NEW WONDER WORLD feel that a word of explanation and interpretation of their aims and purposes in the conception and preparation of this set of books will be welcomed by parents, teachers and librarians.

Present-day education presents a challenge and offers an opportunity. It calls for a new appraisal of the entire field of knowledge from the point of view of its relation to the child; it invites a new method of approach, both *to* the child and *by* the child, to his subject. In the old days there was a fairly definite body of information which it was considered essential to "administer" to the child. This was presented in his textbooks and by his teachers in suitable amounts at prescribed ages, with as much regularity and as little deviation from schedule as were observed in the preparation of his three meals a day.

In recent years the searchlight of attention has been turned on the child. How does he approach a book? What attracts him to it? What does he seek to find there for himself? What do others want him to find? The educator of today, whether teacher or writer, surveys the tremendous circle of knowledge to see what will have a present or future bearing on the child's own life, and then strives to present the selected knowledge in a way that will be really interesting.

However, the selection cannot be made entirely for the child. Within reasonable limits he should be allowed to make his own selection. No longer is it sufficient for him to be told given facts within the bounds of a brief, neat statement. He should be allowed to wander for himself through the fields of knowledge, to browse here and there at will, often being led far afield by the allurements of a path of learning on which he unwittingly finds himself.

In creating THE NEW WONDER WORLD, the editors and writers started with the idea that everybody is interested in everything that is interesting, and that all worth-while knowledge can be made interesting if rightly presented. This led to the adoption of the "unit plan"—that is, the treatment of broad fields of interest in connected, easy-flowing narratives—rather than the customary alphabetical arrangement of material. OUR WONDER WORLD, the predecessor of THE NEW WONDER WORLD, had already shown the great advantage of this method, which is that it presents knowledge to juvenile readers in the form of really entertaining reading and thus skilfully conceals from them the underlying educational purposes of the volumes. Children turn to such books for entertainment as well as for school reference material and therefore spend many more hours with them and derive much greater educational benefit than is possible with the conventional, alphabetically arranged reference set.

With the generous and eager cooperation of the publishers it has been possible to make THE NEW WONDER WORLD a definite embodiment of the new principles of education and a reading and reference work entirely in line with present educational needs. THE NEW WONDER WORLD may sum up its distinguishing features in two words—selection and unity. With their knowledge of elementary and high school curricula the editors have been able

to select what will supplement and enrich the textbook material in prevailing use and supply the desired reference material. And their knowledge of child psychology has enabled them to present this material in a style which attracts and holds the child's willing interest. No attempt has been made to cover every conceivable subject. The aim has been to select those subjects most directly applicable to the needs of children from pre-school through high school; and by the elimination of obscure, little-used subject matter it has been possible to present the material included in a more complete and attractive form than could otherwise be achieved.

The second guiding principle—that of unity—is adhered to through the unit plan of arrangement. For example, in THE NEW WONDER WORLD the subject of astronomy is covered in a continuous narrative, "The Open Book of the Heavens." Instead of classifying the sun under "S" in one volume and the moon under "M" in another, there is presented a unified story beginning with man's first conceptions of the universe and leading right through to the most modern astronomical knowledge. By a carefully worked out sequence of material, the child is led naturally from one fact to another, all in one self-contained narrative and without the necessity of searching through numerous volumes.

It will readily be seen that this unity of subject matter is a great aid to accessibility of the material, as well as to its interest. Yet in spite of this, great care has been bestowed upon the index and every precaution has been taken to make it absolutely complete, accurate, and in every way in accordance with modern library and school standards.

Biographies of great men and women have been given an important place in THE NEW WONDER WORLD not merely for their information content but for their character-building value. And, in keeping with the unit plan, these life stories of famous people are located, insofar as possible, right with their achievements—astronomers with astronomy, artists with art, inventors with inventions. Also, an extensive biography fact-index precedes the general index in Volume Eleven.

One important aim of THE NEW WONDER WORLD is to help children acquire experience in the wise use of leisure. Special interests and hobbies find their inception both in and out of the schoolroom, and teachers and parents frequently discover that they have neither the time nor the material with which to encourage these trends. Here they will find a large quantity of material which will give added information and furnish further guidance to children who are reaching out beyond school requirements and into outside interests to satisfy their active minds and hands. THE NEW WONDER WORLD contains numerous suggestions for games, sports, plays, creative handiwork, and other activities which will guide the child in the selection of wholesome pastimes and occupations.

One of the wisest uses of leisure is, of course, cultural reading. The value of reading as a leisure activity is receiving tremendous emphasis. Educators strive to develop this use of leisure by the introduction into homes and schools of interesting books of high literary quality, which through their appeal to the child will start him along the path of this cultural development. THE NEW WONDER WORLD has recognized this aim. Special emphasis has been placed upon the style in which the volumes are written, and great care has been taken to maintain a high standard of literary excellence throughout the stories, both classic and modern, which are presented.

Finally, it has been realized that education is no longer the province of a special separated group. It must cover in its aims the child's whole life and bring within its circle all those who touch his life helpfully. Here parents, teachers and leaders of boys and girls in group work must meet with intelligent understanding of one another's purposes. In the eleventh

volume will be found a series of articles by prominent educators on some of the most important phases of education. Here the parent will be let into the secret of the aims of school training and the way in which he can best aid in furthering those aims. Here the teacher will come into contact with the point of view of recognized leaders. Helpful outlines and plans for both parents and teachers are included, thus making specific the theories set forth. These do not dictate the use of the volume; their use depends on the way each parent and teacher may find them most helpful. They do, however, outline the best educational practice and offer suggestions which will guide teachers and parents to the fullest use of all volumes.

As Editor-in-Chief I wish to express my appreciation of the splendid work performed by the many educators, artists and writers who have participated in the creation of these volumes. Their high standards of accuracy and their constant care to present their subjects in the most interesting manner made our editorial work a real pleasure. And to our Editor, Miss Marion F. Lansing, who labored unceasingly for several years to co-ordinate their efforts into one harmonious whole, is due the very greatest credit.

Too much cannot be said in appreciation of our Art Department, which has succeeded in making THE NEW WONDER WORLD truly noteworthy for the great number and excellent quality of its illustrations. Many rare and unusual pictures were obtained through special permission, many others prepared especially for this work. All are directly text-connected and were carefully chosen from world wide sources for their high degree of interest and educational value. Generous use has been made of three and four color process printing. Mechanical excellence of all illustrations has been assured through the use of special coated paper, fine-screen half tones and unusual care in printing.

It is with genuine pride that we, the editors and publishers, present THE NEW WONDER WORLD, which we believe to be as interesting and attractive as any storybook, yet supplying the reference material demanded by present school methods and the aid and guidance in outside activities which make for the full, well-rounded development of the child. We hopefully dedicate these volumes to the youth of America, upon whose knowledge and character the future of our country depends.

J. R. McGaughy

Volume I

THE WORLD AND ITS PEOPLES

Naught avails in science, till the light
you seize from heaven shines through the
clear sharp fact beneath your feet.

ALFRED NOYES

TO BOYS AND GIRLS

VOLUME ONE IS CALLED "THE WORLD AND ITS PEOPLES"

DR. GERALD S. CRAIG is the editor of the first half or more of this book. He is a real scholar in the field of science and is famous for his scientific books and articles written for boys and girls. His part of the book tells you many interesting things about the sky and the earth and the sea which you probably never even dreamed were true, but each single fact has been carefully checked by Dr. Craig. He is a professor in Teachers College, Columbia University, New York City. A good deal of his time he spends in teaching science to school youngsters of your own age.

Part of Volume One was written by Dr. Hervey W. Shimer, another very interesting man of science. He is Professor of Paleontology in the Massachusetts Institute of Technology. He knows all there is to know about fossils. From these remains of early birds and fish and animals buried in the rocks, Dr. Shimer reads for us all kinds of interesting things about the life on earth thousands of years ago.

Many other interesting people have helped to make THE WORLD AND ITS PEOPLES a book which you should enjoy reading from cover to cover. Charles A. Wilson, for instance, lived for many years in New Zealand. He tells you a lot of interesting stories about the people who lived long ago in that interesting country away out in the sea. Mr. and Mrs. Deming worked together to give you the finest material we could secure concerning the Indians of America. Mrs. Deming did most of the writing and Mr. Deming, one of the most famous artists of Indian subjects, painted the pictures that illustrate Mrs. Deming's writing. They are all new pictures painted especially for this book.

We must not take the space to tell you of all the other persons who have had an important share in making Volume One. You will become acquainted with them as you read through the book, or as you read the special articles and stories they have written. We shall be delighted if you enjoy their work as much as we think you will.

J. R. McGaughy

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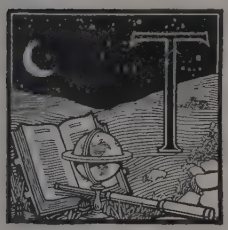
GALILEO OBSERVING THE HEAVENS

THE OPEN BOOK OF THE HEAVENS

HOW PEOPLE READ IT OF OLD, AND HOW THEY READ IT NOW

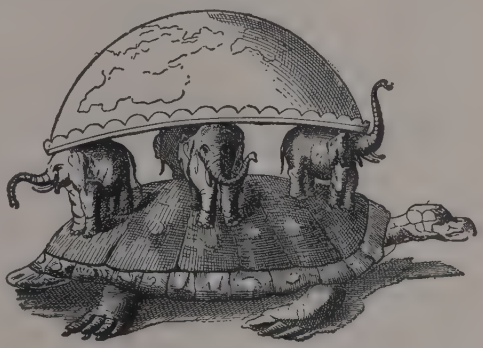


THE heavens are an open book in which the stars are the golden letters. All one need do is to go out after dark and look up, to see what a wonderful and fascinating book it is, and to wish to read at least a little way in it. Here are the stories of how the worlds were made and set on their endless travels along the sky tracks; of our earth and its place among the countless balls that go swinging through space; of the sun that heats and lights our world and keeps it from running off its track; and of all the strange things that puzzle us. No fairy book is half so good as this, which in truth has many fairy stories in it, as you will see.

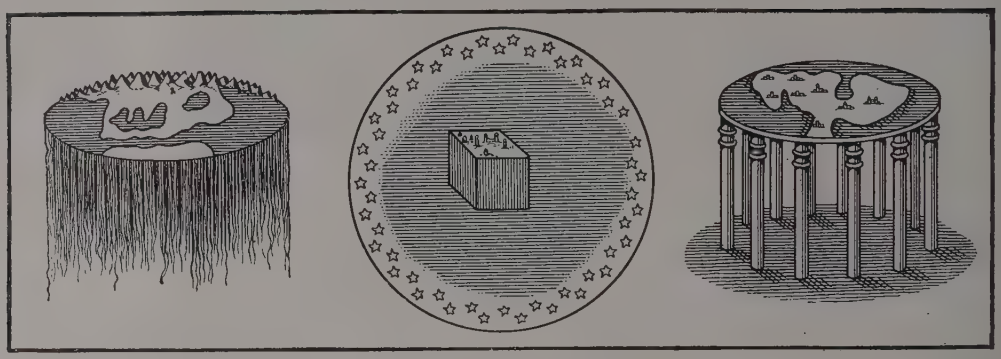
For in the olden days, when the world was young, men did not know so much about the heavens, and so they imagined more. They talked about the sun and moon and stars as if these were alive. They feared them and often worshipped them as gods. They saw that every night light was swallowed up by darkness, but in the morning light came again; and they pictured this daily change as a great world-war in which the demons of darkness and evil were fighting against the gods of light and goodness. Every day, every month, every year, this battle was fought, and the people prayed and sang at sunset and sunrise, hoping that darkness might not conquer forever, but that dawn might come again and light triumph once more over darkness, good over evil, as it always had.

WHEN PEOPLE THOUGHT THE EARTH WAS FLAT

All the ancient peoples thought the earth was flat, or, if not perfectly flat, a great slightly curving surface. But if the earth was flat, what held it up, what did it rest on? On the backs of four elephants, said the Hindus. And what did the elephants stand on? On the back of a great turtle. Why a turtle? Because in the ancient animal beliefs the turtle stands always for strength, endurance, and length of days; and it would take a very strong and steady animal to hold up the world. But why the four elephants on his back? Elephants were strong, too. They could carry a very heavy load on their broad backs; and there must be four, so that they might stand at the four points of the compass — North, South, East, and West. You see, they had an idea, though you may think it a foolish one.



THE TURTLE THAT SUPPORTS THE WORLD



FLAT EARTH WITH ROOTS PLATO'S EARTH CUBE FLAT EARTH RESTING ON COLUMNS

ANCIENT IDEAS OF THE EARTH

The Chinese thought the earth was a great flat disc or plate, with China right in the center of it. Off from China there stretched other lands, and these lands reached out in every direction until they came to a great mysterious, marvelous ocean, which no man could ever reach. This flowed round the whole earth, and here dwelt pygmies and giants and all manner of strange monsters. People in other lands thought the earth floated on a great ocean, just as a lily pad floats on the surface of a pond, and that to keep it in place long, long roots reached down, nobody knew how far, into the water.

But if the earth was flat, what about the sky? The sky, they said, must be a big hollow half-globe, like the inside of a ball. Take a big bowl and hold it bottom side up above your head, and you will see their idea. The sky, of course, must be held up somehow, for it did not seem to rest on the earth. So they thought there were columns round the earth which held it up. And what did the columns rest on? Nobody knew, so there they stopped their guessing.

WHERE DID THE SUN GO AT NIGHT?

There was another question. The sun rose in the east every morning, and set in the west every evening. Then how did it get back to the east to rise again the next morning? It could not go through the earth. Did it go under the earth? That the ancients could not dream of, for was not the earth solid and fast, firmly set on the bottom of the universe? If you began to picture the sun getting under the earth, nobody knew what might happen next. So they told some remarkable stories of the way the sun got from west to east during the night. Some said it fell into the sea which surrounded the earth, and was quenched by the water, and that the gods then set to work and labored all night making a new sun to start the next morning in the east. But that was too absurd to be believed very long. A great body like the sun could not be used up in a single day. So they said that one of the gods, Vulcan, met it when it set in the west and took it into his boat, and rowed with it very fast all night round the ocean by the north until he came to the east. Then he took it and gave it a toss, starting it on its journey again.

GREEK IDEA OF THE SUN PUZZLE

THE SUN-GOD APOLLO

The Greeks saw the sun rise in the east, travel up across the heavens, and sink in the

APOLLO DRIVING HIS SUN HORSES

west, and they thought of it as a god, the great god Apollo. They told how he started in the morning with his chariot drawn by swift horses, and drove with the clouds for his attendants across the heavens and swiftly on towards the golden gate of sunset. Sometimes, they said, Apollo grew weary, and let other gods try to drive his chariot for a day. Then there came trouble and danger for poor earth dwellers; fiery heat and drought when the driver swung the chariot too near, and darkness when the great sun-car was swept out of its right course and clouds shut it from view.

THE WORLD TREE

Up in the Northland men watched the sun rise, and as its rays spread out across the sky they said, "This looks like a tree with branches. Perhaps the world is a tree." So they believed in Yggdrasil, the great World tree. The strong path of the sun was its trunk, the rays of light were its branches, clouds were its leaves, and the sun, moon, and stars were its fruit. This is the description of it from an old German song:

"A gallant tree is growing high,
A garden gay adorning.
Its roots run down to hell below,
Its crown to heaven above doth throw,
Where God doth sit in golden glow;
Its branches take the morning:
Its branches spread the whole world through,
Distilling manna, dropping dew,
And birds thereon are singing."

When you hang gilded nuts and candy animals on your Christmas tree, you do it in memory of this old belief, which has come down to us through these hundreds of years in this German custom. You choose an evergreen tree for your Christmas tree, because the World tree never dies but is ever green, ever living. The gilded balls are for the sun and moon and stars, which hang on the branches, the bits of cotton and tinsel are for the clouds, and the sugar animals are the sacred animals, dear to gods and men, which run up and down its branches.

All sorts of stories were told about these World-tree animals. On the branches there was an eagle, and about the roots, gnawing into them, was coiled a great serpent. The eagle and the serpent were always at strife, and a little squirrel spent his time running up and

A TWELFTH CENTURY PICTURE OF THE EARTH AS A TRAY FLOATING ON THE WATERS

down the branches trying to make peace between them. Lightning came in the heavens

because one of the animals ran across the tree. When it was a curving flash, men knew that the serpent had come out; if it was a zigzag flash, the goat was running about. When the old Germans hung their little festival tree, long before they became Christians, they were very careful to put on the tree every one of the sacred animals, for if you forgot and left out one, the god to whom that animal belonged might be angry and send punishment upon you.

So men told stories — one nation one story and one another — about the wonders of the heavens. We who have read further into the book of the heavens than they, find that the true story is far more wonderful than any which men could imagine. The old stories were interesting, but they did not really explain things. They told how things looked, but they could not tell why they looked so. So wise men set themselves to study the stars and find out how to explain their movements. With the working on these questions real star-study began. The Greeks did a great deal of it. Hipparchus, who lived in the second century B. C., was the greatest of their astronomers. It is from them that we take our name, *astronomy*, from the Greek word *astron*, meaning "star," and *nomos*, "order" or "arrangement."

Astronomy became at that time the study of stars and their order.

WHAT WAS IT THAT MOVED?

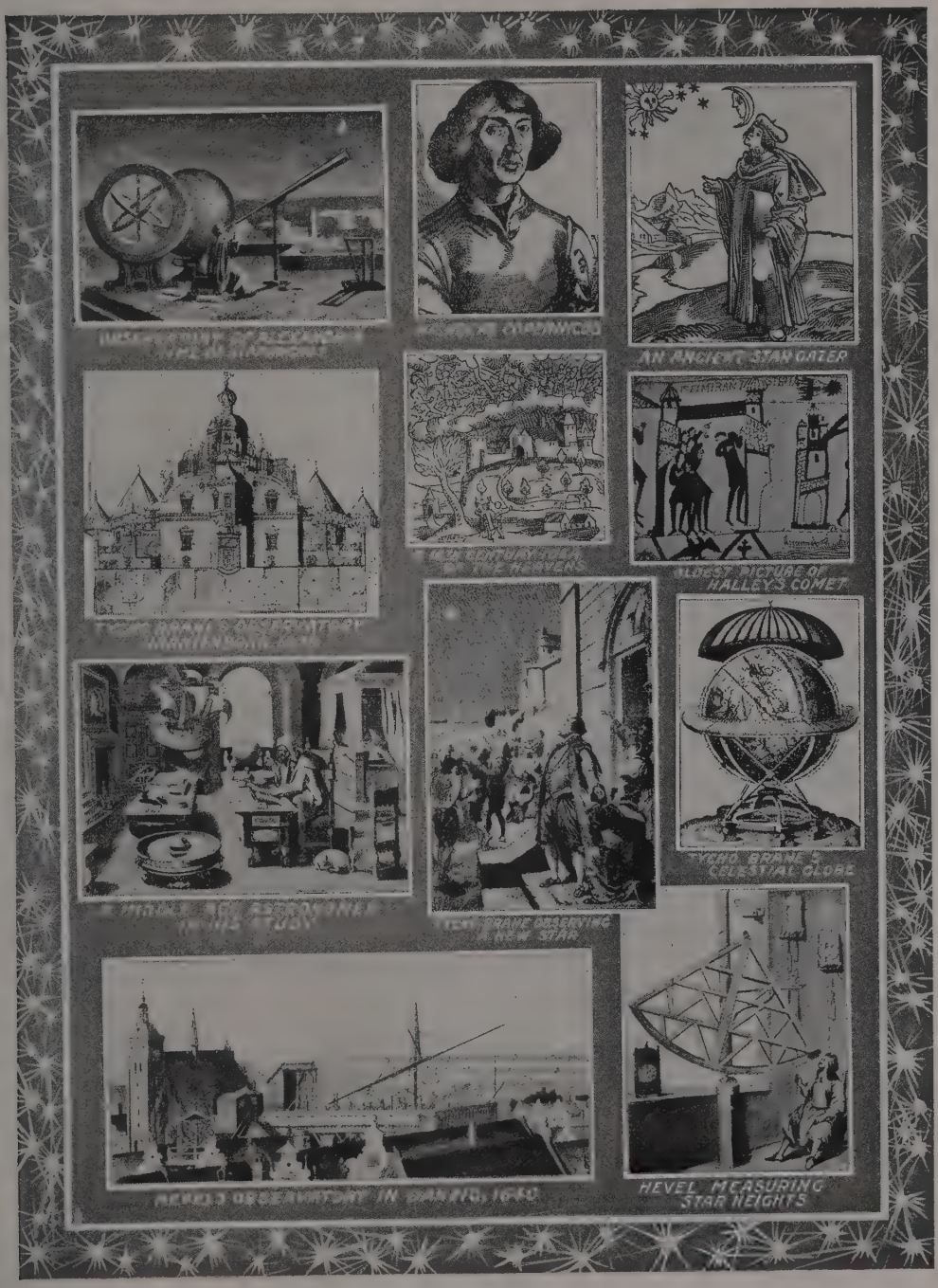
The first question these star students asked was, What was it that moved? Something moved. Anyone who watched the heavens by day or night could see that. But what was it, and how did it move? The more men studied the heavens, the more sure they were that the movements of sun, moon, and stars were regular. The year came round with its four seasons in regular turn, the days became longer and then shorter, the moon came and went at regular intervals. As they studied more and kept records of when these things happened, they found that they could even tell beforehand when these events and many more were going to happen. But how account for it?

The Greek astronomers found out a great deal about the travel habits of the stars, but they could not learn the whole truth, because they thought the earth was set in the center of the universe and could not be moved. They gave up the old idea that nothing could pass under the earth. Some of them even came to think that perhaps the earth was not flat, but curving or partly rounded, like a rubber ball partly flattened out. They made a picture in their minds something like this: The heavens might be a great hollow ball or sphere with the sun and moon and stars tightly fastened to the inside of it. The earth, too, must be fastened somehow, they did not know how, in the center of this hollow space, and the hollow sphere kept turning round the earth, carrying the sun and moon and stars with it.

This was the plan which had for its story the Greek myth of Atlas, the earth bearer, who rebelled against Jupiter, and was condemned in punishment to hold up the world on his shoulders. From him we take our name for a book of maps of the world, *atlas*, a name first used for this purpose by the great map maker Mercator, who called his book of maps an atlas and put on the title-page a picture of Atlas holding the world on his back. Atlas stood in the center of the universe, and about him this hollow sphere was constantly turning, to the inside of which the sun, moon, and stars were neatly fastened.

ATLAS
SUPPORTING THE EARTH

This hollow sphere plan accounted for some sort of movement of sun, moon, and stars. The trouble was that it did not account for it very well. Certain known facts about the time of their movements did not fit into it. For instance, while this plan allowed the sun and moon to move round the earth, it did not make them move in the right time. The sun took apparently a twenty-four-hour day to go round. But then the sun seemed also to take three



ASTRONOMERS AND OBSERVATORIES OF THE OLDEN TIMES

hundred and sixty-five days to make a circuit of the stars, while the moon took from twenty-seven to thirty days for a like journey. Ptolemy, an Egyptian, who lived in the second century after Christ, tried to plan it all out. He made a most elaborate and complicated system. Some stars seemed nearer than others; and they all had circles of their own in which they turned. Back of our stars — the stars we could see — he imagined another set of spheres, which made up a great machinery out of sight that managed the movements of our stars. Altogether it was a most impossible scheme. We do not wonder at young King Alphonso X of Spain, who, when he tried to understand it nearly a thousand years after Ptolemy had proposed it, said that if he had been the creator and had been planning the universe, he would have found a simpler way to arrange it.

This was a rash remark for even a king in those days, for the people might be led to think a man unfit to be a king who spoke so irreverently. But King Alphonso was right. The stars in the heavens move after a much simpler plan, a plan discovered three hundred years after King Alphonso's time and about fourteen hundred years after Ptolemy, by the great astronomer Copernicus.

Nicholas Koppernik, whom we know under the Latin form of his name, Copernicus, was born in Poland in 1473, and died in 1543. This was just the period, as you see, when Columbus was trying to convince people that the earth was round. Copernicus was a poor boy; his father was a tradesman. But his uncle was a bishop in the cathedral of Frauenburg, Poland. This uncle took the boy and had him educated, first in the church schools and later in the universities, and he became for a time professor of mathematics in Rome. He did not stay long in Rome, but went back to his uncle's cathedral, becoming a canon of the church, and devoting all the time which was not needed for preaching or visiting the sick to the study of astronomy.

COPERNICUS AND HIS GREAT DISCOVERY

Night after night Copernicus sat up in one of the cathedral towers and watched the movements of the stars. He had read all the old books on astronomy, but they did not satisfy him. He realized that Ptolemy's theory was proving more and more impossible, as more facts which did not fit into it were found out. Copernicus watched and watched, and thought and thought, and at last his great idea came to him. Perhaps the earth was not the center of the universe about which everything else revolved, but only one small revolving part of it. Perhaps the earth itself moved. For years and years he worked on this idea, and proved that the earth not only turns round once in twenty-four hours, but is only one of the planets, all of which revolve round the sun.

This discovery by Copernicus is one of the greatest discoveries of science. Copernicus helped us to know how very big our universe is; and we know now that Ptolemy was wrong and Copernicus was right. Copernicus wrote his beliefs in a famous book which he called "The Revolutions of the Heavenly Bodies," but the book was not published until after he died. So it was left to others to defend his ideas. One of his able followers was Galileo.

Although Copernicus was very close to the correct explanation of the motions and relations of the sun and planets, there were some things which he could not account for. We know now that this was because he thought that the orbits of the planets were circular instead of oval.

Newton, whose studies of gravity are of such great value, helped later to perfect the ideas of the solar system as given by Copernicus.

THE SWIFT-SPINNING EARTH

It is very hard to tell which of two objects is moving unless you can compare them with something which is outside them both and standing still. You can readily notice this when you are sitting in a train at a station, and there is another train on the other side of yours. For if one of the trains moves gently, either yours or the other, you cannot tell which one it is unless you look at the station platform; and if your position remains the same in regard to that, you know that your train is still standing, while the other one beside it has begun to move. And it is very likely that there is no one of us who has not, at one time or another, stood on a bridge and watched the water

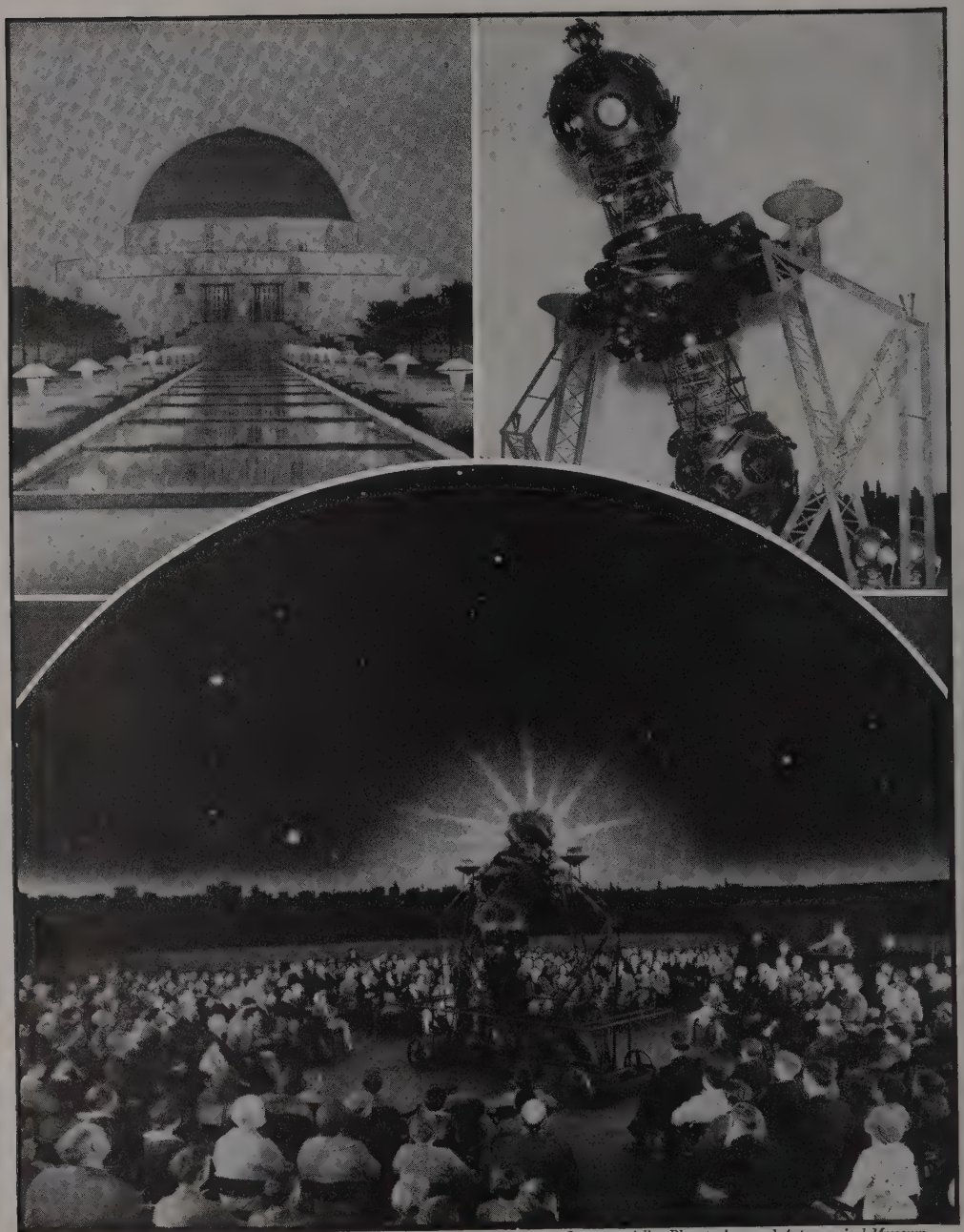
running away underneath until we felt quite dizzy, and it seemed as if the water was standing still and the bridge, with ourselves on it, was flying swiftly backwards. It is only when we turn to the banks and find them standing still, that we realize that the bridge is not moving, and that it is the running water which makes it seem to do so. These everyday instances show us how difficult it is to judge whether we are moving, or an outside object, unless we have something else to compare with it. And the marvelous truth which Copernicus thought out is that, instead of the sun and moon and stars rolling round the earth, it is the earth that is spinning round day by day, while the sun and the stars are comparatively still; and, though the moon does move, yet when we see her get up in the east and go down in the west, that is due to our own movement and not to hers.

WHY WE HAVE DAY AND NIGHT

When people found this out, they could explain a great many things which had been a puzzle for centuries. One was the old question of "where the sun went at night." Instead of the sun traveling round the earth, it was the earth which moved, spinning round like a top once a day. Only one half of the earth can be lighted by the sun at one time. One half of

THE SPINNING EARTH ON WHICH WE LIVE

Note that the earth's speed increases as you get farther from the pole.



Courtesy, Adler Planetarium and Astronomical Museum

PORTRAYING THE DRAMA OF THE HEAVENS

These pictures show the Adler Planetarium in Chicago, the first planetarium built in America. On the curved ceiling of the central auditorium a complicated projector, invented by Carl Zeiss, throws beams of light representing the sun, moon, planets, and principal stars. Their correct positions and motions for any period of time in the past, present, or future can be shown. If you live in or visit a city which has a planetarium, be sure to attend one of the fascinating demonstrations which are given several times daily. Upper right is a close-up view of the Zeiss projector.

TIME AROUND THE WORLD, AS THE EARTH REVOLVES AROUND THE SUN

Courtesy of the Postal Telegraph-Cable Co.

A WORLD-TIME CLOCK

On which pointers show the time at cities all over the world when it is high noon at Washington, D. C. The upper portion of the clock-face is dark to represent night, the lower portion, bright to represent daylight. Here, too, are shown the divisions for standard time in the United States.

the earth then is always having day while the other half is having night. As the earth spins about, it is turning different parts towards the sun. It takes the earth just twenty-four hours to spin round once. That is why we have day and night, and also why it is daytime in China, on the other side of the earth, when it is night with us. This also explains why some people of the earth are going to bed while others are getting up, why some people are eating breakfast while others are listening to bed-time stories, and why the clocks in different parts of the earth strike different hours at the same time.

If you take an orange and stick a knitting needle through it, and hold it so that the needle is not quite straight up but a little slanting, and then twirl the orange round and round on the needle, you will get quite a good idea of the way the earth turns round, though of course there is no great pole like a needle stuck through it. But there is an imaginary line through the earth which takes the place in our minds of the needle, and the points where this line comes to the surface are called the north and south poles.

This imaginary line is called the earth's axis. When astronomers talk of this spinning motion of the earth, they say the earth is turning or rotating on its axis.

WHY WE HAVE FOUR SEASONS IN THE YEAR

Day follows night, and night day, because the earth spins round like a top once in every twenty-four hours. Spring follows winter, and autumn summer, because of another motion of the earth. All the time that the earth is spinning round on its own axis like a top, it is also making a 365-day-long journey round the sun.

You remember that when we talked of the earth as spinning on itself, we pictured it either as a top or as an orange with a knitting needle stuck through it, and we said that the knitting needle should be not quite straight up and down, but tilted a little to one side. That was because the earth is tipped in just such a way in its relation to the sun. It is this tip of the earth in its path round the sun which makes our seasons. If the earth were not tipped, if it stood right up straight from pole to pole, there would be no winter or summer, for each part of the earth would be turned towards the sun an equal part of each twenty-four hour day. But it is tipped, and therefore we have winter and summer; and because this tip affects different parts of the earth differently, the seasons come at different times in the north from those in the south.

FROM SUNRISE TO SUNSET OF AN ARCTIC DAY

The camera was focussed on this scene, and exposures were made every fifteen minutes in order to show the passage of the sun. Notice the moon peeping up above the trees.

EQUAL DAY AND NIGHT

Some tops, mounted in a movable frame suspended on a stand, can be made to spin not only up straight, but with the axis at any inclination. No matter how you move the stand about, the axis of such a top will always point in the same direction, and keep parallel to its first position. This is the way with the earth in its path or orbit round the sun. It spins on its axis always parallel to one direction. Hence, at one part of its journey, during June, the north pole of the axis will be tipped toward the sun, while six months later, in December, it will be tipped away from the sun.

If you watch the sun on March 21st, you will find that it rises directly where the compass points to east, and sets where it points to west. At this time the earth is tipped so that both the north pole and the south pole are equally in line for the sun's rays. Neither is tilted towards the sun more or less than the other. So on this date, day and night will be of exactly equal length in all parts of the world. The sun will be seen above the horizon just twelve hours everywhere. This day is called the *equinox*, which is the Latin for "equal night."

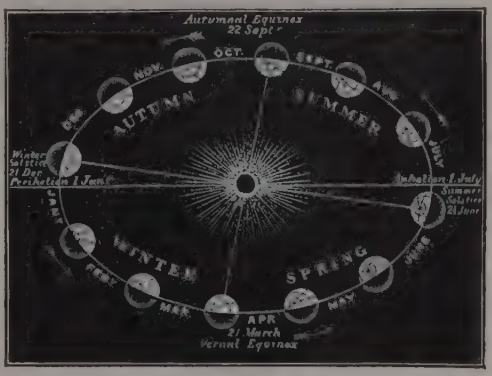
SPRING AND EASTER

March 21st marks the beginning of spring. Easter Sunday, the Sunday on which is celebrated the resurrection of Jesus Christ, is always the first Sunday following the full moon which occurs on or next after March 21st. If the full moon falls on a Sunday, Easter is the next Sunday. Thus the date of Easter may come anywhere between March 22nd and April 25th, a period of thirty-five days. Because Easter is a spring festival, the early churchmen of England gave it a name in the English language that was derived from Eostre, or Ostara, the Anglo-Saxon goddess of spring.

Spring begins on March 21st because, as the earth passes the vernal equinox and continues its journey around the sun, the northern part — this northern hemisphere on which we in America live — is towards the sun, and so gets more and more sunshine, until on the 21st of June we have our longest possible day, when the sun is above the horizon for nearly eighteen hours.

THE SUN-STAND-STILL

All this time, if you have been watching the sunrise and sunset, you will have noticed that instead of rising due east and due west, as it



WHY WE HAVE FOUR SEASONS

In June, the northern part of the earth is turned towards the sun and has summer. In December, the southern part of the earth is turned towards the sun and has its summer, while the northern part is having winter.

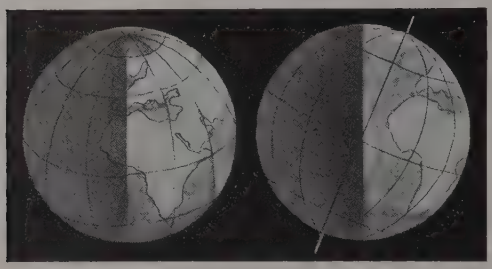
did on the day of the spring equinox, the sun has been rising more to the north of east and setting more to the north of west.

If one watched the sun at different times of the year, he would find it looks as if the sun traveled northward during the spring and southward in the autumn. The ancients thought it really did travel about the earth in some such way.

We know now that it is not due to the sun traveling but to the tilt of the earth's axis. The earth is always tilted so that its north pole is pointing toward the North Star. As the earth makes its yearly journey about the sun, it arrives at a position where most of the light and heat of the sun falls on North America, Europe, and Asia, the southern part of the earth being on the opposite side away from the sun. Europe, Asia, and North America will now have summer. But on June 22nd, the light of the sun will have reached the northernmost limit — the sun seems to stand still.

That was the way it looked to the Romans, who thought the sun was making the journey, so they called it the summer solstice or "Sun-stand-still."

As far back as history goes, men have known about and kept time by these solstices. The Chinese, more than four thousand years ago, used to celebrate the time of the solstice, in



EQUINOX AND SOLSTICE

On March 21 and September 22 days and nights all over the earth are equal. On June 21 the North Pole is having its long day; the South Pole its long night.

the hope of persuading the sun, by their dances and festivals, to delay his departure towards the equinoxes.

WHY WE HAVE AUTUMN AND WINTER

The earth always keeps on spinning and traveling about the sun. It never stops. It runs very smoothly. It does not jiggle and jar like most trains and automobiles. As it travels about, it always keeps its axis pointed in the same way, with its north pole toward the North Star.

This causes the sun to seem to move southward after the 21st of June. The earth in its journey about the sun is beginning to turn the northern part of the earth away from the sun. The days grow shorter for all the people living in the north, until, on the 22nd of September we have the Autumn Equinox, when once again day and night all over the earth are of equal length. The autumn has begun. We know that the days will get shorter and shorter, until on the 21st of December we have our winter solstice, our shortest day in the year. The earth continuing its journey about the sun, tilted as it travels about the sun, now has the southern part of the earth turned toward the sun. Southern South America, South Africa, and Australia now have summer, while North America, Europe, and Asia have winter. The earth continues its journey and on March 21st, the earth has equal days and nights.

Why then, you may ask, do we have the long, cold winter after the 21st of December, and the hot summer after the 21st of June? If the earth is beginning to tip back, why do we not feel it at once by warmer weather in January? The answer to that question belongs to another story, of how heat is held by the earth. All we can tell you here is that this earth of ours takes the sun's rays and stores them. If it did not, our coldest day would be just when you would expect it, on December 21st, when we have the sun's rays for the shortest time, and our hottest day would be June 21st, when we have them longest. But the earth and the air have a way of storing up heat and cold and then giving it out slowly, which makes our hottest time and our coldest time come along for a month or two after the solstices.

HOW THE SUN TELLS TIME

The earliest way to tell time was by the position of the sun. Primitive man reckoned in two main periods, day and night, and divided day by sunrise, noonday, and sunset. Then he began to divide the morning and the after-

A SUNDIAL OF TO-DAY

noon into sections by noticing the length and position of shadows. He set a stick upright in the ground, and found that the shadow cast by it grew longer and shorter and moved round the stick. This was the origin of the sundial, which is used to this day. By the length and direction of shadows cast by the sun, men could

calculate the time to hours and minutes. All ancient peoples told time by sundials. The Chinese had them. The Romans set up tall stone shadow columns, with officers to watch them, whose duty it was hourly to cry out the time as shown by the length and position of the shadows. Even when water-clocks and hour-glasses had come into use in the Middle Ages, the common people, who could not afford such luxuries, told time by sun-clocks, which every father of a family could make for himself. Sometime you must try to make a sundial for yourself; but meanwhile, you and the sun together make up the cheapest and least complicated clock in the world. Study your own shadow, its length, and the way it points, and you will be able to tell from it within an hour the time of day. The Romans did this constantly. Pliny, the great writer, says in one of his letters: "I beg thee to honor my house when thy shadow will be six feet long." Everybody who lives much in the woods learns how to reckon time by the shadows of the trees.

Shadow-reading is not the best way of telling time, because the sun does not always shine. But shadow-reading is not the only way which depends on the sky-clock. All our modern clocks are regulated by astronomers, who check them up each day by the position of certain fixed stars. The astronomer keeps time for the world, and he takes his time from the sky-clock, the most marvelous clock of all, which through all history has gone with unfailing accuracy, never stopping for a second, never going faster or slower, but keeping steadily on, with the rotating earth for part of its works and the star-set heavens for its face.

This sky-clock makes for us the cheapest and least complicated clock in the world. There is no mechanism of any kind to get out of order or for man to care for. And the clock is running just as accurately now as it did thousands of years ago, and will be running thousands of years from now.

Our day, month, and year are fixed by the movements of the earth, moon, and sun. The day is fixed by the length of time it takes the earth to spin on its axis. The month comes from the word moon and is fixed by the length of time (29½ days) between new moons, which is the lunar month. The year is the time (365¼ days) required for the earth to make its journey about the sun.

THE SUN

What is this sun, about which the earth revolves, this giant sun on which we depend for light and heat, for day and night and times and seasons, and even for light itself? The ancients worshiped it, and well they might, for there would be no earth or people on the earth if it were not for this light-giving, heat-giving, life-giving sun.

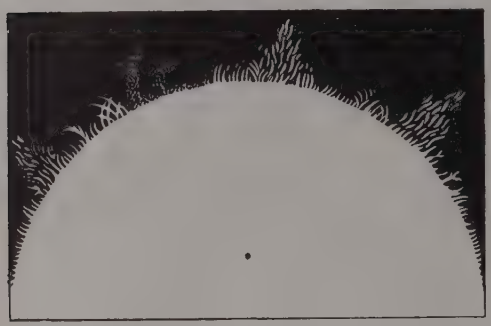
We see it as a great ball of light, rising higher and higher from the east until midday, and sinking slowly towards the west, where it disappears in a blaze of glory. This is one of the cases where our eyes tell us the truth. The sun is a great ball of very hot gases, giving out to all the worlds about it a tremendous amount of heat and light. More than that we cannot find out until we get some idea of how big this ball is, and how far away it is. These are questions men have been asking since the beginning of time. Only within a few hundred years have they been answered.

SIZE AND DISTANCE

We have seen from our study of the earth's motion how hard it is to tell whether objects are moving or are standing still. It is just as hard to judge how big an object is and how far away it is. Did you ever ask a group of people on some summer evening to tell how large the moon looked to them? Try it some night. One person will probably say that it looks the size of a cart-wheel to him; another will speak up at once and say, "Oh, no, it does n't look nearly so large as that to me. I should say a dinner-plate"; another will say a face, and someone in the group may insist that it looks no larger to him than a cent. Probably no two persons in that company will agree on the size which the moon appears to be. Yet they are all looking at the same moon; and what is more important, they are looking at it from the same place at the same time. So, first, in our star study as in all other study of the world in which we live, we have our human eyes to reckon with, and

well as they serve us, we have to check up what we seem to see by measures and tests to make sure it is quite true.

Try another experiment with the moon. Close one eye and hold a silver quarter at arm's



THE EARTH A PINPOINT COMPARED WITH THE SUN

The diameter of the sun is 865,000 miles; that of the earth only 8,000 miles. This picture shows the streams of gases shooting out from the sun.

length between the other eye and the full moon. The silver quarter will shut out the great bright globe entirely from your sight. Still you don't really think that the moon is smaller than a silver quarter. Why is it, then, that the quarter can shut out the moon? It is because you put the quarter so close to your eye. A very small thing held close to your eye can shut out a very big thing at a distance from your eye; and a very large object can look very, very tiny if it is far enough away. You know how that is if you have ever stood on top of a mountain and looked down to try to find a house and street in the valley. The house seemed very large to you when you were beside it, but now it is only a tiny dark speck. So, at the very beginning of our story, we learn that things are not always just as they seem to be, and that a small globe close at hand may look as large as a very big one far away.

When we come back to the sun, we have to think of all this, for the sun is really a giant star, tremendously big, but no bigger than and even not so big as some of the other stars in the heavens; and tremendously far away, but still not so very, very far away as are some of the other stars.

HOW FAR AWAY IS THE SUN?

Quite lately men have been able, with the help of wonderful instruments, to find out how far away from the earth the sun is. What do you think they found? The distance of the sun from the earth is about *ninety-three millions of miles!* Can you picture that to yourself?

Try to think what is meant by a thousand miles. Our earth is eight thousand miles in diameter. In other words, if you were to thrust a gigantic knitting needle through her body, from the north pole to the south pole, it would have to be about eight thousand miles long.

To reach the thought of one million, you must picture *one thousand times one thousand.* Our earth is about twenty-five thousand miles round. If you were to start from the mouth of the Amazon River in South America, and journey straight round the whole earth on the equator till you came back to the same point, you would have traveled about twenty-five thousand miles.

But that would be a long way off from a million miles. You would have gone only once round the earth. Now a rope one million miles in length could be wrapped, not once only, but *forty times* round and round the earth.

And when you have managed to reach up to the thought of one million miles, you have then to remember that the sun's distance is ninety-three times as much. So to picture clearly to ourselves the real meaning of ninety-three millions of miles is not easy.

Suppose it were possible to fly by airplane from here to the sun. If you could journey thither in a perfectly straight line, at the rate of two miles a minute never pausing for one single minute of the day or night, it would take more than eighty-eight years to reach the sun. If you had started your trip at the time of our Civil War you would not have reached the sun yet. (This idea is carried out in pictures on pages 32 and 33.) If you had to pay for your journey at a rate of two cents a mile, it would cost you nearly two million dollars.

Yet the sunlight which floods the earth each day travels every mile of that immense distance and makes the whole trip from the sun to the earth in eight and one-third minutes.

THE GREAT SIZE OF THE SUN

So much for the sun's distance from us. Now as to its size. The earth is eight thousand miles through from pole to pole. This sounds a great deal; but the distance through the sun is eight hundred and sixty-five thousand miles.

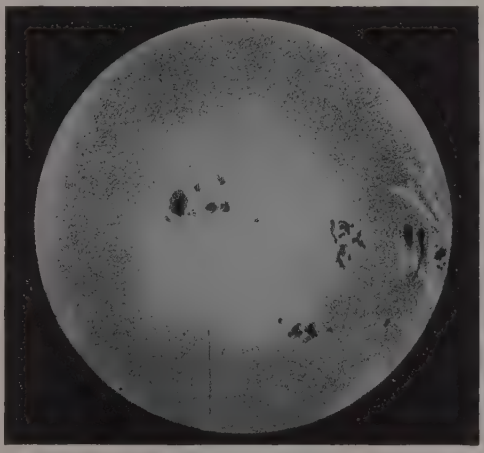
Suppose you had a long, slender pole which would pass through the middle of the earth, one end just showing at the north pole and the other at the south. You would need more than one hundred of such poles, all joined together, to go through the sun. But, after all, we cannot really understand either how big the sun is or how far away from us, for our minds refuse to take in such great figures.

SUN SPOTS AND WHAT THEY TELL US

What is the sun really like? It is hard to tell, for we cannot look straight at the sun because of its dazzling brightness. But a telescope shows us a great deal. Only remember that you must never look at the sun even through a telescope without protecting your eyes with colored glass, else you will be very likely to blind yourself, or hurt your sight very badly. When we first look at the sun through the telescope (which is a long tube so fitted with mirrors and glasses that it helps us to see things which could not be seen with the naked eye), it looks like a broad, round, white disc, shaded a little at the edge, so that you can see it is not really flat, but a globe. And here are two or three little black splashes upon the whiteness, looking as if somebody had spilt some ink on the paper. Now, these black splashes are the famous sun spots which tell us so much about the sun. They do not look very wonderful, do they? But let us try to think what they really are like. They measure often many thousands of miles from side to side, and some of them are so big that you could lay ten worlds upon them in a row, and still the spot would not be altogether covered.

In the beginning of the seventeenth century a man named Fabricius was startled by the sight of a certain black spot upon the face of the sun. He watched till too dazzled to look any longer, supposing it to be a small cloud, yet anxious to learn more. Next day the spot was there still, but it seemed to have moved on a little way. Morning after morning this movement was found to continue, and soon a second spot, and then a third spot, were observed creeping in like manner across the sun. After a while they vanished, one at a time, round the edge, as it were; but after some days of patient waiting on the part of the lookers-on, the spots appeared again at the opposite edge, and once more began their journey across the sun from east to west.

Fabricius seems to have been the first, but he was not the last, to watch sun spots. Many astronomers have given close attention to them. Modern telescopes, and the modern plan of looking at the sun through darkened glass, have made this possible in a way that was not possible two or three hundred years ago. For more than thirty years one astronomer kept close watch over the spots, on every day that it was possible to see the sun. Much has been learned through his resolute perseverance.



THE SUN'S SPOTS

WHAT ARE THESE SPOTS?

No one can actually say what they are. Some astronomers think they are great hollows in the sun's surface, where the stuff which has been thrown out, and which has got cooled, is gradually settling down again. But this is not at all certain. All we can say is that the spots are

caused by great storms and eruptions within the sun, and that they tell us that this great globe is not solid and steady, like the earth, but is constantly tossing and heaving up and down, almost like water boiling in a kettle.

If you look at a sun spot for several days, you will notice that it is always changing. In a day or two it might look quite different from what it did at first; sometimes the changes come so quickly that parts of the spot as big as our world alter their shape in a few hours. So you see that the sun can scarcely be a place that you would like to live in. Even if you could stand the heat, which would melt in a moment the hardest things we know of, you would find that there was nothing solid to put your feet on. Great fiery waves would always be rising and falling around you; every now and then jets of flame would shoot up thousands of miles high; and sometimes huge gulfs, in which worlds might be swallowed up, would yawn beneath your feet.

HOW WE KNOW THAT THE SUN TURNS ROUND

You will see, however, if you watch a spot carefully, that another kind of change is taking place. It is near one edge of the sun at first. Next day, it will be a little nearer the middle, and, in about twelve and a half days from the time it first appeared, it will be going out of sight at the edge opposite to that where you first saw it; while, if you wait another twelve and a half or thirteen days, you may see it coming back again just where it first appeared. Do you understand what that means? Remember what we found out about the time it took the earth to spin round once. When a sun spot takes twelve and a half days to go from one side to the other, and another twelve and a half to come back into sight again, that means that the sun turns round in twenty-five days, just as our world does in twenty-four hours. The first important discovery made through the spots on the sun was that the sun turns round upon its axis in just the same manner that the earth turns round upon its. Only — and this is the strange thing — the sun does not turn all at the same speed. Our world spins round all in a piece, and, if it did not, it would probably fly all to bits; but some parts of the sun take twenty-five days to turn round, some take twenty-seven, and some take longer still.

CHANGEABLE SPOTS AND THE "LITTLE TORCHES" OF THE SUN

It must not be supposed that the spots seen now upon the sun are the same spots that Fabricius saw. There is perpetual change going on — new spots forming, old spots vanishing; one spot breaking into two, two spots joining into one, and so on. Even in a single hour great changes are sometimes seen to take place. Still, many of the spots do remain long enough and keep their shapes closely enough to be watched from day to day, and to be known again as old friends when they reappear, after being about twelve days hidden on the other side of the sun. So that the turning of the sun upon his axis has become, after long and careful examination, a certain fact.

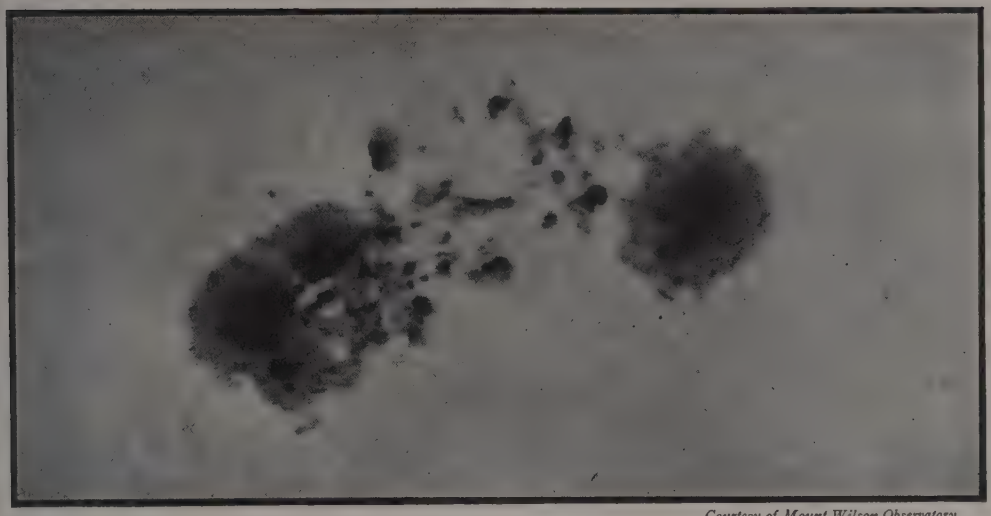
Sun spots are believed to be caused by whirling masses of electrified particles just beneath the outer layer of the sun. These whirling masses of electrified particles have magnetic fields, the effects of which are felt even on the earth. They cause our magnetic storms.

The sun spots are thought to interfere with the radio and to cause Northern Lights, or Aurora Borealis, which are seen in Arctic regions, during their long winter night.

There are other marks on the face of the sun, which you would notice at once through the telescope. Near the edge, and generally close to a spot, you will see white markings of all shapes and sizes, looking as if they were the crests of the fiery waves thrown up by the solar storms. Astronomers call them *faculæ*, or "little torches." And all over the surface there is a beautiful delicate mottling of gray and white, which sometimes makes the face of the sun look rather like a plate of rice soup.

THE SUN A HUGE BUBBLE

Thus the sun is very different from what you would imagine when you see it shining day by day. Indeed, if we thought of it as a great bubble we would not be very far wrong. Of course, this is such a bubble as you never dreamed of — a bubble far bigger and heavier



Courtesy of Mount Wilson Observatory

A SUN SPOT GROUP

than all the worlds that go round about it put together; a bubble which, instead of being made of soapsuds, is made of iron, lead, lime, and all sorts of other things, heated so hot that they have become glowing gases. Think how enormous the heat of this tremendous bubble must be! We sometimes feel the sunshine uncomfortably hot on a summer day, but we may be thankful that the sun is so far away from us, for if it were to come even as near to us as the moon does we should scarcely have time to feel uncomfortable. We should simply shrivel up and vanish, and our solid world would melt, like a drop of wax in the flame of a candle.

WHERE DOES THE SUN GET ITS GREAT POWER?

For thousands and thousands of years this tremendous flood of light and heat has been pouring out from the sun. How does it keep it up? Mere burning can never account for such heat. It is true that the sun is so enormous that it might go on burning for a very long time without burning right away; but then, even if it is huge, this expenditure is also huge. If the sun had been made of solid coal, it would have been all used up in about six thousand years, burning at its rate. Now, we know that the ancient Egyptians kept careful note of the heavenly bodies, and if the sun was really burning away it must have been very much larger in their time; but we have no record of this; on the contrary, all records of the sun even to five thousand years ago show that it was much the same then as at present.

Yet how can the sun give out heat energy except by burning?

We said that the sun is made up of metals and gases at a very high temperature. Metals, gases, all things in fact, on the sun, our earth, or in the universe, are known to be made up of little units called "atoms."[1] We have atoms of iron, making up a piece of iron; atoms of lead, making up a piece of lead; atoms of hydrogen, making up that gas. And we have lately discovered something most remarkable, that these little atoms are made up of particles of electricity bound together. Electricity, you know, is energy. It does all kinds of work for us; gives us light, runs machines, heats toasters, and is put to many other uses. So that, finally, we find that the sun is made up of electrical energy bound together into the little units called the atoms. But you ask, if the electrical energy is bound fast in the atoms, how does it get out of the atoms from the sun to us?

[1] For more about atoms, see Volume Ten, page 312.

If some force should start shaking these atoms hard enough and fast enough, some of the particles of electricity making up the atoms would be knocked loose, and often some of those knocked loose would return to their former places in the atoms. Whenever particles of electricity are either knocked loose from an atom or knocked into an atom again, small amounts of energy are given out. This process is taking place all of the time in the sun and part of the resulting energy makes up our light and heat.

There are two possible explanations of all this activity in the sun. One is based on the fact that when gases contract they create heat. If the huge gaseous bubble we call the sun is slowly contracting, immense amounts of heat and light are thus created. Another and more recent theory is that the sun contains "radio-active" substances such as uranium and radium which are constantly giving off energy in huge quantities. We say that this energy radiates to us from the sun through space. Some of the energy from the sun is in a form that we cannot detect without scientific instruments but some we feel, calling it heat, and some we see and call it light.

HOW THE LIFE OF THE EARTH DEPENDS UPON THE SUN[1]

We on the earth are absolutely dependent upon the energy or power which the sun gives us: not only because this energy gives us light and warmth, but because without it we could not get anything to eat; nor would we have the stored-up energy of fuels, such as coal, oil and wood.

When we do work, whether by hand or machine, we use up energy and this energy must come from somewhere. To move the train, the locomotive uses the energy of steam secured from coal. The automobile moves because of energy obtained from gasoline. We move because of energy obtained from food. But have you ever thought about where the energy of the coal, gasoline, and food comes from? If you consider it carefully, you will find that the energy for doing all of these kinds of work comes from the sun.

In tracing the sources of energy back to the sun, you will become aware of the fact that energy can be changed from one kind into another. Energy of motion can be changed into energy of heat. When you rub two sticks together, they get hot and can even be made to burn. And just the reverse of this process may take place, with heat energy being changed back into energy of motion. The energy of the hot steam pushes the wheels of the engine. And electrical energy can be changed into heat and light, as you know, from observing the coils of wire in the electric toaster.

Life on the earth depends upon the energy of the sun being made useful to us by means of changes from one form to another.

Let us trace through a few of these energy changes from the sun. Green plants take some of the energy of the sun and store it as food. The plant dies, falls to the ground, and is buried for thousands of years, thus forming coal. We burn the coal, getting heat and steam. The steam runs the dynamo which makes electricity. The electricity gives us light. So you see, here we have traced through four changes in the sun's energy. First to plants, then steam, then electricity, and then light.

Or the green plant, which has stored the energy from the sun, may be eaten by man, thus giving vital energy. This energy he uses to play, read, or think. So here again we have a series of changes, from sun to plant, plant to body, from body for work or play.

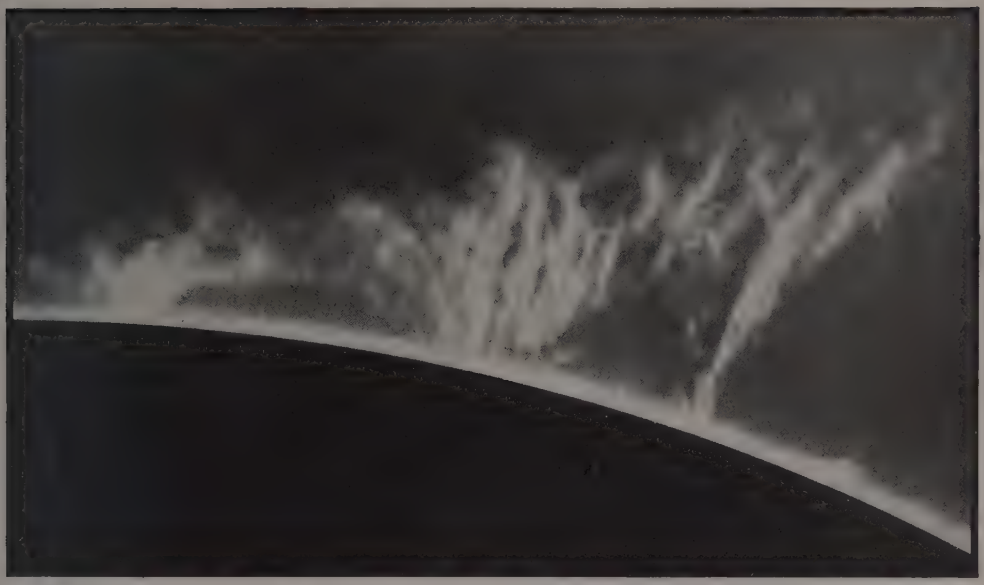
There may be many changes before we use the energy of the sun, but in every case the energy came first from the sun.

The story of our earth would be quite different if it had no sun to shine on it every day. It would be a cold, dark earth, without sunshine, clouds, rain, plants, or animals.

WHY WE DO NOT SEE THE STARS DURING THE DAY

The sun is usually the only heavenly body which we see by day, but this does not mean that the sun is the only one which is shining by day. The moon and the stars are shining just the same; but the sun is so bright that it outshines them all. Sometimes in the late afternoon you can see the moon shining faintly,

[1] See also Volume Ten, pages 46-63.



Courtesy of Mount Wilson Observatory

A PHOTOGRAPH SHOWING MASSES OF GAS SHOOTING OUT FROM THE SUN

Prominences like these are always streaming out from the sun. The one in the picture reaches a height of 80,000 miles.

and once in a while you can even see a few stars; but it is only when the sunlight has been gone an hour or two that we can really see the moon and stars in their brilliance.

The strange part of it is that while on earth we can see farther by day than by night, when we turn to look at the heavens we can see much farther by night than by day. No one knows how far we can see at night; but some of the stars which we see when we go out after sunset and look for the first stars are either those which seem bright to us because they are near, as star-distances are reckoned, or they are very large stars. The moon looks largest of all to us, not because the moon is itself very large, but because she is our nearest neighbor in space.

THE MOON AND THE EARTH

Not only is the moon nearer to us than the other stars, but it really belongs to us. It is our moon. Jupiter has moons. Other planets have moons, though much smaller ones than ours; and this is our moon, our attendant, or as the astronomers call it, using the Latin word for "attendant," our *satellite*. Just as we move round the sun in a path which it takes us 365 days to travel, so our moon travels round us in 27⅓ days; but because the moon moves in common with the earth round the sun we see the new moon only every 29½ days. This period is a lunar month. So the moon is part of our sky-clock, too, giving us our months, while the sun gives us days, seasons and years.

There is another reason why the moon belongs to us. It used to be a part of us. Once upon a time, the astronomers say, as the earth was turning round and round in her course, a fragment broke off from her. This fragment was our moon. It did not go right away from the earth, but still went on circling round with the motion which it had when it was a part of her. As the ages passed, the earth and this wandering piece have stayed near each other.

The moon is about 250,000 miles from the earth. Astronomers call this very close indeed, and so it is, compared to the distances of sun and stars; but if we were not thinking in star-distances we should call it very far. It is 25,000 miles round our world. If a man starts to travel

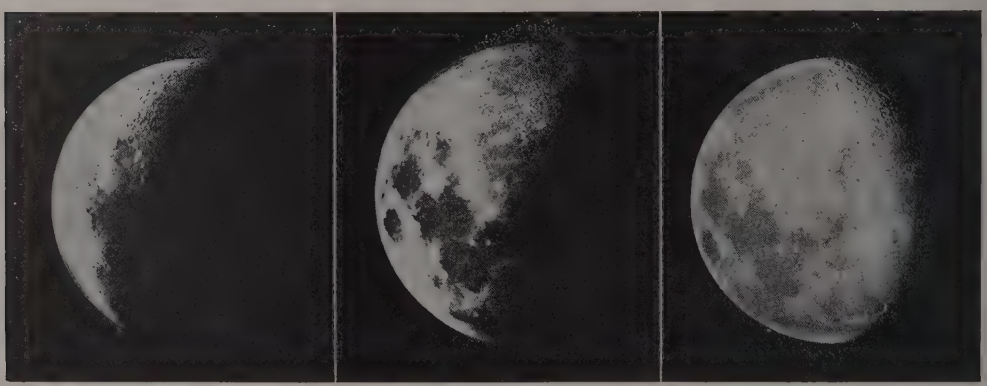
around the world at the equator and could average a mile a minute he would still need 17 days for the circuit. But if when he arrived at his starting-point, he set off once again, and then again, until he had been round ten times, he would then have traveled only as far as from the earth to the moon. But if any kind of traveling would ever bring him to the moon, he could go round it in much less time, for one journey round the earth would equal about four round the moon.

WHY THE MOON SEEMS TO CHANGE HER SHAPE

The sun seems always round and bright, but the moon is always changing her shape. You see her first as a thin crescent of light, quite close to where the sun has set. Night after night she grows broader and rounder, till she is quite full — a great silvery globe rising in the east as the sun sets in the west; and after that she gradually loses her roundness again, till you see her in the early morning before the sunrise, a pale crescent, with her horns turned the opposite way from those of the evening crescent.

Now the moon does not really change her shape any more than our earth does. The reason she seems to is because she borrows her light from the sun. Strange as it may seem, the moon has no light of her own. She gets it all from the sun, just as we on earth do. It is only because the sun gives light to the moon, and the moon reflects it to the earth, that we are not left in the dimness of starlight all the nights of the year. The moon has no light of her own because she has no heat of her own. She has no heated gases from which to shed light, as the sun does. But she can reflect the light which the sun sheds on her. But just as we who live on one side of the earth cannot see the sun all the time, so, as the moon turns round, only part of the moon gets the sunlight at one time. Again, the way the moon turns round us, she does not ever show all of herself to us, but she keeps one face, one side of herself, towards us all the time. Sometimes this face is all reflecting sunlight, sometimes only part of it. One half of the moon is always lighted by the sun. The part of the moon which we see shining brightly is that section of the moon's surface which is both lighted by the sun and also turned towards us. Half the moon's surface is lighted by the sun at the very time when we are seeing only the crescent moon, but it is not the half which is turned towards us. Only that section of *our* side of the moon which is being lighted by the sun can be clearly seen by us. The other part is in shadow.

When we see the moon first in the western sky above the sunset, it is a slender crescent of silvery light, and is about two days old. That is, it is about two days since the moon passed between the earth and the sun. Night after night it grows in size, until about five days after we see it first, it is half full. Then at



AS THE MOON WAXES

At 6 days | At 8½ days | At 12 days

sunset it has made half its daily journey across our sky, and has reached what almanacs call its "first quarter." It continues to grow for about another week, until one evening it is our full moon. It rises just as the sun sets. The half facing us is fully lighted, for exactly the same half is facing the sun. Then slowly its size decreases. It rises later and later, and grows smaller and smaller, until when it reaches its "last quarter" it is to be seen only in the morning hours. The moon is going back to its place between the earth and the sun; for about a week of this time it is out of sight.

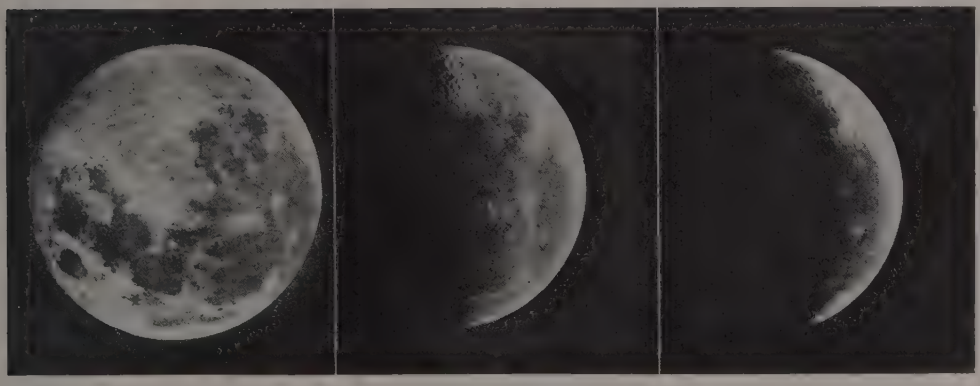
MOONSHINE AND EARTHSHINE

But sometimes we can see the crescent moon, and also very, very faintly the outline of the full moon back of it. That is what people mean when they talk of "the old moon's lying in the new moon's arms." The bright crescent is being lighted by reflected sunlight. But what then is giving this light to the other part of the face, which would naturally be in black shadow? That light comes from our earth. This is one of the sights in the heavens which reminds us that we too are a shining globe floating in space and appearing bright to others while they are shedding their light on us. Like the moon, we borrow our light from the sun. The sun's rays strike us and are reflected to the moon, just as they strike the moon and are reflected to us. While the earth is being lighted by moonshine, the moon is being lighted by earthshine; and from the moon the earth must appear a much bigger and more glorious sight even than the moon does to us, for we are forty-nine times as big as the moon, and four times as wide across. If there were people on the moon they would see the earth sometimes "full" and sometimes "half-full." They would speak of "full-earth" and "half-earth." The earth is also turning different parts of its surface to the moon while spinning on its axis, and while the moon travels round it. So when we see this faint outline of the moon full outside the crescent, it is the reflection of our own earthlight coming back to us.

THE MOON A DEAD WORLD

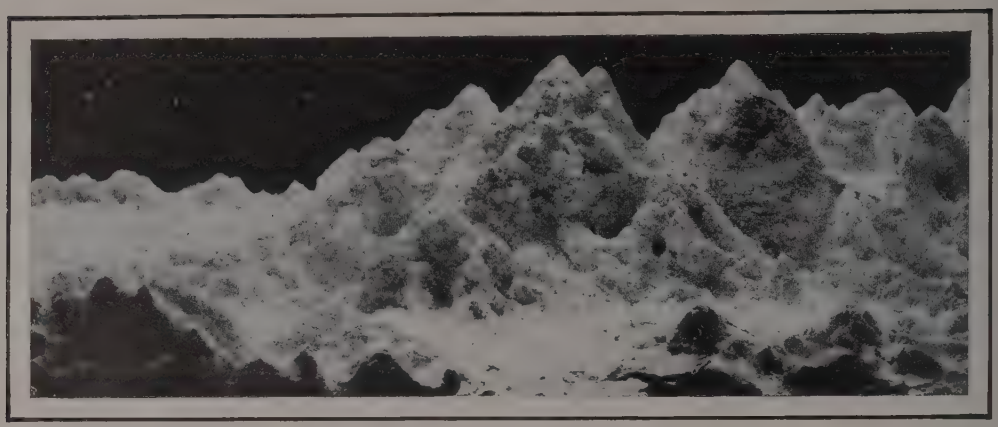
We cannot go to the moon, and perhaps it is just as well, for astronomers tell us that if we went there we could not live for a single instant. The reason would be that there is no air around the moon. All round the surface of our earth there is a great blanket of the air we breathe; but the moon is a dead world.

If there is one thing we have found out certainly about the moon, it is that no life, as we know it, could exist there, for there is neither air nor water. Whether she ever had any air or water, and if so, why they disappeared, are questions we cannot answer. We know only that now she is a dead world. Bright and beautiful as she is, shedding on us a pale, pure light,



AS THE MOON WANES

At 15 days | At 21½ days | At 23½ days



SOUTH POLE MOUNTAINS ON THE MOON
As imagined by an artist who looked through a telescope

in vivid contrast with the fiery yellow rays of the sun, yet she is lifeless and still.

FIGURES IN THE MOON

One sign that the moon is a dead world, without air surrounding it, is that it looks so clear to us. Clouds sometimes come between us and the moon, but they are earth-clouds. There are no moon-clouds because there is no air. So the moon, when we can see it, is always clearly outlined against the sky. It is a perfect crescent or half moon, not a disc that shades off into space or into bright rays, as the sun does. Another sign is that we can look at it at all. If the moon had flames of its own like the sun, and were so near us, not only could we never look at it; probably we should not be a world at all, for a blazing body so near us would have burned us up long ago.

When we do look, what do we see? As it grows from crescent to full, dark patches begin to show on it. It does not look all smooth and even and equally bright, but bright in one place and shadowy in another. These dark and light spots seem, as we look at them, to make great faces and figures, and because the moon keeps the same face towards us all the time, they are always the same, and have been for thousands of years. The biggest face is the one we see when the moon is full or almost full, and we call it the "Man in the Moon." People in the olden days saw this man, and another man, too, the whole figure of a man with a bundle of sticks on his back.

WHAT IS THE "MAN IN THE MOON"?

What is the "Man in the Moon"? What is it on the moon's surface which makes these light and dark places which look from the earth like faces and figures? If we look through a telescope, we see them very differently. But first let us picture ourselves standing outside both earth and moon on another star, — perhaps the planet Venus, for it is in a position which would give us a good view.

Now if we should happen to stand upon the planet Venus, and her veil of cloud were drawn aside to give us a clear sky, we should see a very pretty sight. Shining brightly against the dark background of the sky would be what seems a double world, made up of one big, bright star and a smaller star quite close to it. If we had a telescope, we should be able to make out a great many features of the bigger star. We should see that it had glittering white ice-caps at the poles, and that its whole surface was flecked over with patches of brown and green and blue; while here and there brilliant white patches would come and go, blurring the outlines of the other parts. We should see this prettily colored world turning steadily round and showing us different parts of its

surface; and all the time the smaller world near it, which we would not be able to see quite so well, would be circling round the bigger one. The bigger world is the earth we live upon, and the smaller one is the moon; and the two together would make one of the prettiest pictures you can imagine in the sky of Venus.

We never can see ourselves as others see us in that fashion, yet, fortunately, we can get a better view of the moon than of any other body in the heavens, and we can see many most interesting and wonderful things upon her surface. Indeed, even a small telescope will show you quite a number of them, and it would be well worth your while to try and see them for yourself. When you use a telescope, the face of our old friend, the "Man in the Moon," vanishes, and you see a great round silvery globe, very bright in some parts and very gray in others, and altogether looking not unlike a badly peeled orange.

MOON MOUNTAINS

The best time to study the moon is not at full, but when she is half bright and half dark, a week or ten days after the new moon. Suppose we turn a telescope on her when she is like that. When you put your eye to the eyepiece, you find that the moon has grown so big that it can't shine through the telescope all at once, and you have to take it in bit by bit. Look, now, at this piece near the middle of the flat edge. You see it is all full of great black holes, or, rather, it is all covered over with bright rings, which are full inside with black shadow, and look almost like the little cells in a piece of honeycomb. The black shadows are the mountains in the moon, and very strange and wonderful mountains they are.

Scientists are not sure just what might have caused the rings or circles that are formed on the moon. They may have been craters of great volcanoes which belched forth lava, hot gas. We have volcanoes on the earth. The moon is different from the earth in that it is almost covered with them.

Some suggest the craters may have been caused by meteors or shooting stars. These meteors may have struck the moon with such force as to have made craters.

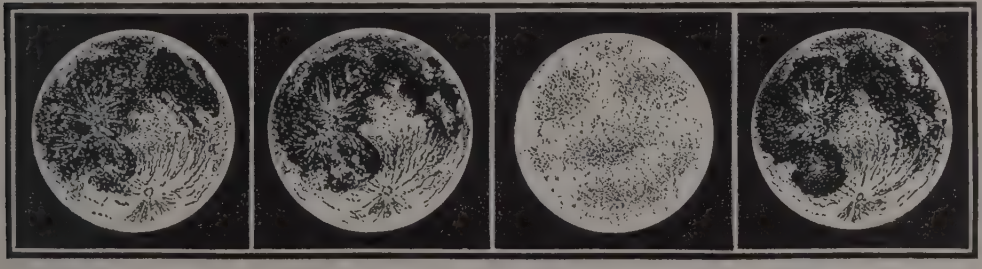
Since there is neither wind nor rain on the moon, there has been nothing to wash away the craters and they look just the same to-day as they did when they were first formed, which was probably millions of years ago.

In the Arizona desert, there is a crater, almost a mile in diameter, that was formed by a falling meteor. Could the craters of the moon have been formed by the falling of giant meteors? Or were they formed by great volcanoes? The astronomers are not agreed.

The craters on the moon are immense, not only in proportion to her size, but even according to our ideas on the earth. One of the largest craters in our own world is in Japan, and this measures seven miles across, while in the moon craters fifty, sixty, and even a hundred miles across are by no means uncommon.

A WORLD OF GREAT MOUNTAINS AND PLAINS

All these mountains and craters show that at one time the moon must have been convulsed with terrific disturbances. If they were made by volcanoes, the moon must have been a most



RABBIT-MOON LADY-MOON MAN-MOON UPSIDE-DOWN MAN

THE MOON, PHOTOGRAPHED THROUGH A TELESCOPE

Telescopes bring the moon so near that its mountain peaks, casting harsh, black lunar shadows, and its craters can be plainly seen. The State of Rhode Island could be fitted into one of the huge craters, and there would still be room to spare. Since the moon has no atmosphere, there can be no wind or rain. This means that there is nothing to wear down the moon's high mountains and to cover over its craters.

KEY TO THE PHOTOGRAPH OF THE MOON, WHICH HAS BEEN ATLASED

The great long ranges are in the northern part of the moon. The moon peak called Mt. Blanc is 12,000 feet high. The craters Aristoteles and Eudoxus are among the great "ring-mountains." The places marked "Seas" are not real seas. They might be called plains since there is no water on the moon.

Courtesy of Harvard College Observatory

MOON CRATERS AND MOUNTAINS

The large crater is about fifty miles across.

wonderful place, but very uncomfortable to live upon; for we have known enough about the ruin wrought by volcanoes in our own world to be glad that we have so few of them. In the moon, of course, they are all burnt out now, and no more smoke or lava ever comes from them.

Volcanoes are not the only mountains on the moon. Here and there are long ranges of mountains, stretching sometimes for hundreds of miles across the surface. If you look through the telescope, you will see a long, curved streak stretching down from below the middle of the moon to the flat edge. That is one of the moon's mountain ranges, called the "Lunar Apennines." You can see it quite well on the full moon with the naked eye, and it makes the nose of the man. But when you look at it with a telescope, you see the great peaks, some of them higher than Mont Blanc, shining almost as white as if they were covered with snow, and the long, black shadows which they cast stretching for many miles across the plain. These shadows are far blacker than any darkness that you ever saw on the world; for all our earthly shadows are softened and made lighter by the presence of our air, but on the moon there is no air at all, or, at least, next to none.

Then there are great, dark places, which by the absence of shadows we know to be plains, hundreds and hundreds of miles wide. These are some of the great dark splotches we see. There are, also, tremendous clefts in the ground, some of them hundreds of miles long, and so deep that no one can tell how deep they are. You have seen the ground cracking in hot summer weather, and opening up into long clefts. Well, these cracks on the moon look very like that, and they were probably caused by the surface splitting as it cooled down from the tremendously hot state in which it once was. Altogether then, you see, the moon must be a very strange place, with its thousands of dead volcanoes, and its long mountain ranges, and these great gulfs seaming its surface. Some of the mountainous parts of the world are wild enough, but we have nothing here that is anything like so wild and rugged as some parts of the moon.

THE EARTH ONE OF A FAMILY

It is rather pleasant to think of the moon as our moon, belonging to us and circling round us. In the same way we are tempted to think of the sun as our sun, moving in the heavens to give us light and heat. But here our pride has a fall. While the sun is our sun because we depend on him and live by him, it would be truer to say that we are one of his little worlds, for the sun is the head of a family of which our earth is one of the tiniest parts. If we study the sun by itself or only as it has to do with our own world, we get no idea of what a mighty force it is. Only when we think of our earth as one of a family of greater worlds, all turning round the sun as we do, and of the sun as the head and ruler of all these revolving worlds, do we begin to have the faintest idea of the sun's importance and power. This marvelous sun family to which we belong is called the "sun system," or from the Latin words for sun, *sol*, the "solar system."

EARTH'S BROTHERS AND SISTERS IN THE SUN FAMILY

When men began to look at the heavens, they found that most of the stars seemed to keep in the same groups and not to change their places. There were the Great Dipper, and the Small Dipper, and a great many other groups which men named from their shape, which kept in the same relation to each other, and have kept so for hundreds and thousands of years. But then there were other stars which seemed to be always moving about. Also they shone very brightly indeed — two or three in particular that are often brighter than any other stars in the sky, and that shine with a much steadier light than the others. You know how the stars are always twinkling and flashing; but, if you watch these two or three, you will see that they scarcely ever twinkle, but keep steadily shining.

These moving stars are really worlds, like our own world, and not stars at all; and they are not nearly as big as even the dimmest and finest of the other stars, no matter how brightly they shine. They look so bright simply because they are much nearer to us than any of the true stars. The name that has been given to them is the "planets," or "wanderers," because they appear to wander among the stars; and they belong to the same family to which our own world belongs, — this solar system. The sun is the center round which all these worlds travel. They move continually round him in rings which are not exactly, but very nearly, circles. Some of these worlds are smaller than our own, and some are very much bigger; but none is anything like so big as the sun, which keeps them all moving round him, and gives them light and heat.

THE PLANETS, OR "WANDERERS"

Of all the objects in the heavens, the planets are the most interesting to us. Though removed from us by millions of miles, they are still nearer than any of the stars. Then, too, they are more like us than anything seen in the sky, for, after all, the earth is only a planet, not a very large one nor a very small one. Counting our earth as one, there are nine of these worlds in our solar system, and also a number of tiny planets, called "asteroids." These likewise go round the sun, but are very much smaller than any of the first nine and stand in a class by themselves, so that when the planets are mentioned it is generally the nine large, well-known planets which are referred to. These make up the solar system, and in it the only thing that shines by its own light is the sun; all the rest, the planets and their moons, shine only because the rays of light from the sun strike on their surfaces and are reflected off again. Our earth shines like that, and from the nearer planets must appear as a brilliant star.

This is the chief distinction between stars and planets. Stars are suns — mighty globes of glowing flame. The planets simply receive the light of the sun, and shine with a brightness not their own.

A lamp shines by its own light; but a looking-glass, set in the sun's rays and flashing beams in all directions, shines by reflected light. In a dark room it would be dark. If there were no sun to shine upon Mars or Venus we should see no brightness in them. The moon is like the planets in this. She has only borrowed light to give, and none of her own.

Any one of the planets removed to the distance of the nearest fixed star would be invisible to us. Reflected light will not shine nearly so far as the direct light of a burning body. There may be thousands or millions of planets circling round the stars — those great and distant suns — just as our brother planets circle round our sun. But it is impossible for us to see them. The little solar system is separated by distances beyond the realm of thought from the rest of the universe. Vast as are the intervals between ourselves and our planetary neighbors, they are as nothing to the space that separates us from the nearest of the steady-shining fixed stars. Why, removed as far from us as the stars, the sun himself would have sunk to a point of light; and as for the planets, the largest of them, Jupiter, could not possibly be seen. Thus, when we look at those stars across the great gulf of space, we know that though we see them they cannot see us, and that to them our sun must seem only a star.

OUR PLACE IN THE SOLAR SYSTEM

The orbits of the planets, as their paths round the sun are called, lie like great circles one outside another at various distances, and do not touch or cut each other. Where do you suppose our own place to be? Will it be the nearest to the sun or the farthest away from him? As a matter of fact, it is neither; we come third in order from the sun, for two smaller planets, one very small and the other nearly as large as the earth, circle round and round the sun in orbits lying inside ours.

If the pathway or orbit of our earth were pictured by a hoop laid upon the table, with a ball in the center for the sun, then those two planets would have two smaller hoops of different sizes *within* ours; and the rest would have larger hoops of different sizes *outside* ours.

A round hoop would not make a perfect picture of an orbit. For the yearly pathway of our earth is not in shape perfectly round, but slightly oval, more like the shape of an egg than that of a ball, and the sun is not exactly in the center, but a little to one side of the center. This is more or less the case with the orbits of all the planets.

But the laying of the hoops upon the table would give a good idea of the way in which the orbits really lie in the heavens. The orbits of all the chief planets do not slope and slant round the sun in all manner of directions. They are placed almost in the same *plane*, as it is called, or, as we might say, in the same *flat*. In these orbits the planets all travel round in the same direction. One may overtake a second on a neighboring orbit, and get ahead of him, but one planet never goes back to meet another.

WHAT BINDS THE FAMILY TOGETHER

Before we talk about these different brothers and sisters of the earth, and their sizes and distances from the sun, let us stop to ask ourselves what it is that keeps this sky-family together. It is the power of the great head of the family, the sun. It has been said that if the comparison were not offensive to the sun-god, we might say that he is like a spider at the center of his web. From the center of his web to his nearest planet is thirty-six million miles; to the farthest, about twenty-eight hundred million miles. But he holds them all in this invisible web by the power of his pull. This mysterious power which the sun has, and the earth has too in a smaller way, is called "gravitation."

WHAT IS GRAVITATION?

The force of gravitation is well known to us in what we call "weight."

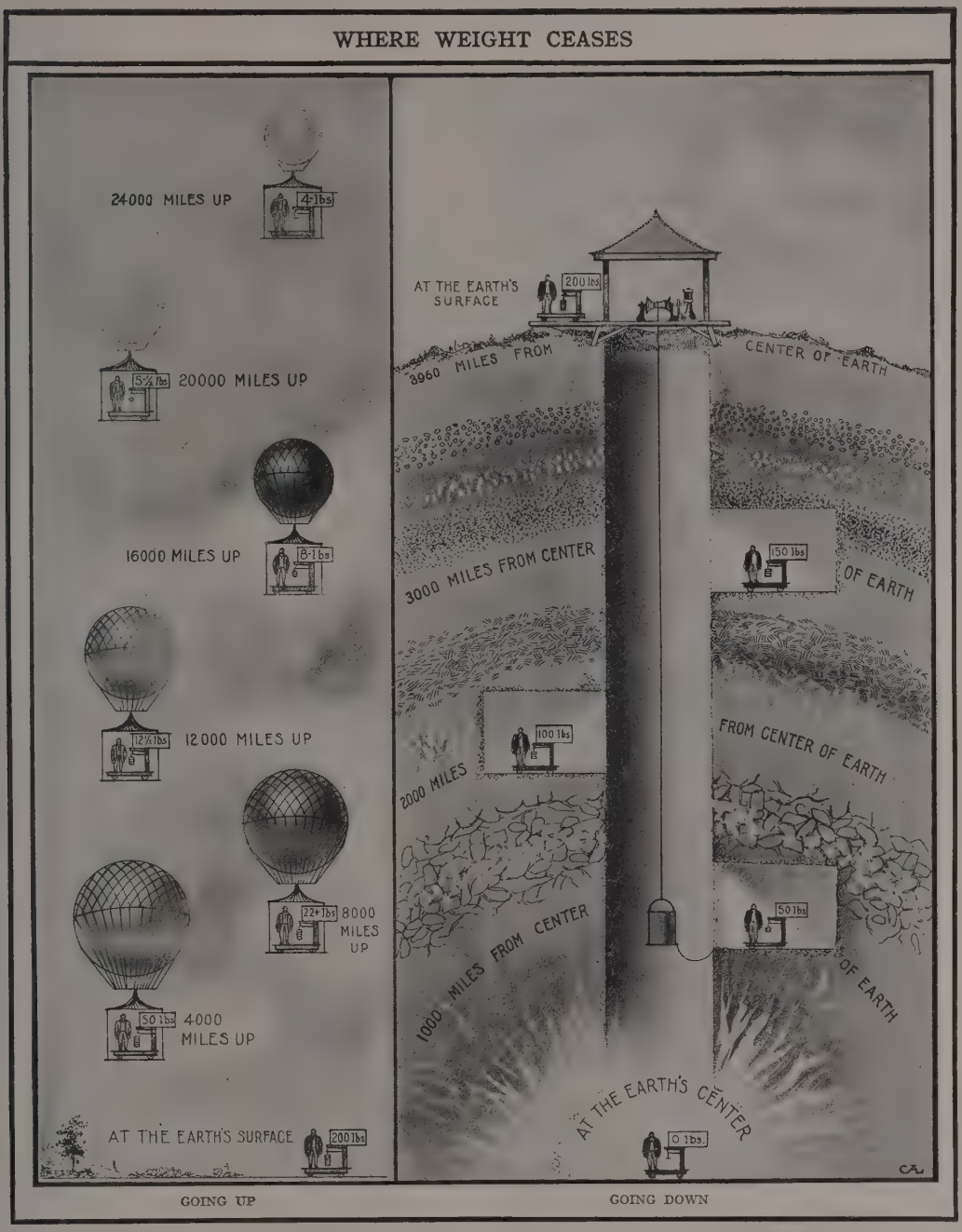
What causes an apple to fall to the ground when it drops from the branch? Why should it not fall up instead of down? Because, of course, it is heavy, or has weight. But what is weight?

Simply this: that the earth draws or drags everything downward towards herself, by the power of attraction. All substances, great or small, light or heavy, are made up of particles. Each of these particles attracts or draws all the other particles towards itself; and the nearer they are together, the more strongly they pull one another.

A ball of iron is heavier than a wooden ball of the same size. Therefore we say that it weighs more, or that it has greater "mass." Weight and mass are not the same, as a ball of iron weighing sixty pounds on the earth would weigh only ten pounds on the moon, if spring balances were used to do the weighing. This is owing to the difference in mass of the earth and the moon.

Now as the earth is immeasurably heavier than anything that is on it, it pulls everything towards itself with such force that the little pulls of other things upon each other are not noticed. The earth draws us all towards it. It is holding us down to it every minute of the day. If we want to move we have to exert another force in order to overcome this attraction of the earth, so we exert our own muscles and lift first one foot and then the other away from the earth, and the effort we make in doing this tires us. All the while you are walking or running you are exercising force to lift your feet away from the ground. The pull of the earth is called "gravitation."

Now precisely as an apple falling from a tree, and a stone dropping from a cliff, are dragged downward to the earth, just so our earth and



THE SAME SIZE, BUT AS LIGHT AS A FEATHER

It is easy to say that weight depends wholly on the law of gravitation, upon the pull of the earth. But it takes an imaginative sketch like this to make us realize it. This man weighs two hundred pounds at the earth's surface. Suppose he starts to take the four-thousand-mile journey to the center of the earth. As he gets down there will be less and less earth to pull him. He might well lose fifty pounds every thousand miles, till at the bottom he weighed nothing. Let him start up in a balloon. Here the whole earth would be pulling him back. Probably his weight would follow Newton's law. If he weighed 200 pounds at the earth s surface, at twice that distance from the earth's center, he would weigh one-fourth, fifty pounds, at three times that distance, one-ninth. and so on.

THE FORCE OF GRAVITY ON DIFFERENT PLANETS

The bigger and heavier a world, the stronger the pull it exerts. In the center is the normal jump of an athlete on Earth; to the right his jump on the Moon, where the same amount of effort would carry him six times as high; to the left his jump on Jupiter, carrying him not quite half as high.

all the planets are dragged towards the sun and towards each other. The law of the earth's attraction of all objects on its surface to itself was dimly suspected a very long time ago; but it was Sir Isaac Newton who first discovered that this same law was to be found working among the members of the whole solar system. The sun attracts or draws towards it the earth, and the earth attracts the sun. But the enormous size of the sun compared with our earth — like a great nine-foot globe beside a tiny one-inch ball — makes our power of attraction to be quite lost sight of in his, which is so much greater.

It was in the year 1666 that Newton, a young man in his home in England, first hit on the idea of gravitation as it affects not only our earth but the solar system. The story goes that while Newton was sitting in his garden he saw an apple fall to the ground. He knew why the apple fell; it was heavy, it was pulled by the earth. He was led to ask if the same force did not keep the moon in its monthly path round the earth, and prevent it from flying off into space. After twenty years he was able to prove by his studies that this was true.

The problem of the ancients was, How could the earth hang in space? It could not, they said; therefore it must rest on something; the shoulders of an Atlas or the waters of an ocean. It could, said Newton, by the power of gravitation — that marvelous, invisible bond everywhere present, working through all space, which keeps the planets under the control of the sun, making order out of chaos, and a solar system out of a group of rushing worlds.

So Copernicus showed us our earth's position in the solar system, and Newton showed us why and how it kept moving.

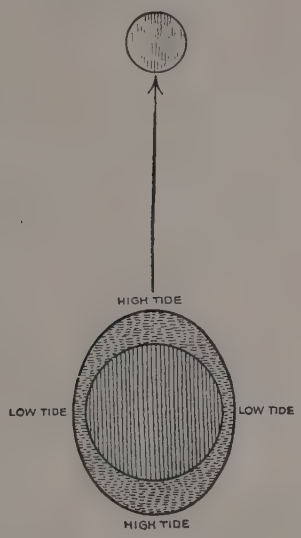
THE OTHER FORCE

But if the force of gravitation is so strong, someone may ask, why does not the sun pull all the planets right to himself and boil them up in his tremendous heat? That is a very good question, and takes us back to the birth of the earth. If the planets were at rest, if they were not moving at all, they would have been drawn right into the sun by the force of gravitation. But they are not at rest. They are going at a tremendous speed. Even this earth of ours is rushing through space at a rate of nineteen miles a second, and it is only because, through gravitation, the garment of air round it moves just as fast, that we do not know anything about this fearful rate at which we are dashing along. All the planets are moving, some three or four miles a second, and others even faster than we. Now it is one of the laws of the universe, which we cannot explain, but which we know, that any object which is moving will keep moving in a straight line unless something interferes with it. We call this "inertia."

We know that, at some remote age, this world, probably very different from what it is now, together with the other planets, was sent spinning off into space on its age-long journey.

But the first force which started the worlds into space followed this law of motion and gave them the impulse to go on in a straight line. So when the sun pulled, the result was a movement between the two: the planets did not continue to move in a straight line, neither did they fall on to the sun, but they went on a course between the two — that is, a circle — for the sun never let them get right away from him, but compelled them to move in circles round him.

The sun's pull and this other force, both of



TIDES, SHOWING THE MOON'S VARYING PULL

which have been acting these thousands of years, explain the solar system of which we are a part.

WHY WE HAVE TIDES

From gravitation to tides seems a big jump, but it is n't a jump at all, for tides are due to the pull of the moon on the earth. Besides giving us light at night, this is one of the moon's great services to us. Without the rising of the sea twice in every day and night our coasts would become foul and unwholesome, for all the dead fish and rotting stuff lying on the beach would poison the air. The sea tides scour our coasts day by day with never-ceasing energy, and they send a great breath of freshness up our large rivers to delight many people far inland. The moon does most of this work, though she is a little helped by the sun. The reason of this is that the moon is so near to the earth that, though her pull is not very strong, it is very strongly felt. The solid part of the earth is not as easily moved as the liquid; so when it comes to the water she can and does work on that, so that the water rises up in answer to her pull, and as the earth turns round the raised-up water lags behind, reaching backward towards the moon, and is drawn up on the beach, and makes high tide. But it is stopped there, and meanwhile, by reason of the earth's movement, the moon is left far behind, and pulls the water to itself farther on, when the first high tide relapses and falls down again. At length the moon gets round to quite the opposite side of the earth to that where she began, and there she makes a high tide too; but as she draws the water to herself she draws also the solid earth beneath the water to her in some degree, and so pulls it away from the place where the first high tide occurred, leaving the water there deeper than before, and so causing a secondary high tide.

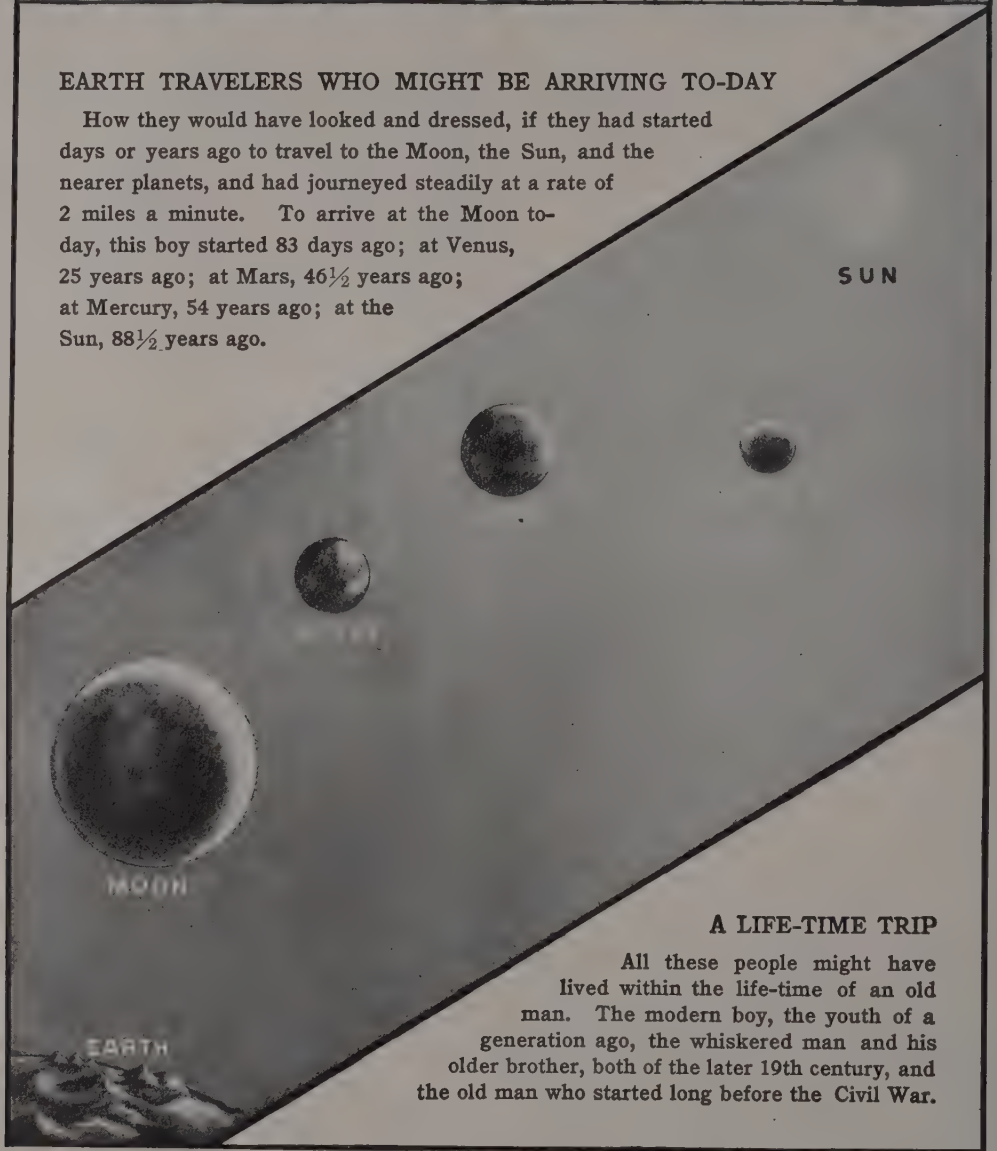
The sun has some influence on the tides too, and when moon and sun are in the same line, as at full and new moon, then the tides are highest, and are called spring tides; but when sun and moon pull in different directions, as when it is half-moon, then the tides are lowest.

THE NINE PLANETS

The planets, as they are held in their paths by the sun, are divided into two groups: the inner planets, Mercury, Venus, Earth, and Mars, and the outer planets, Jupiter, Saturn, Uranus, Neptune, and Pluto. These two groups are separated by a wide belt of the smaller planets, seven hundred or more little worlds, of which the largest is hardly five hundred miles in diameter. The distances of these planets from the sun are so great that we cannot grasp them — not only thousands but millions and hundreds of millions of miles; but there is one curious fact about them. Within the inner circle, and again within the outer, each planet after the first is, very roughly, about twice as far from

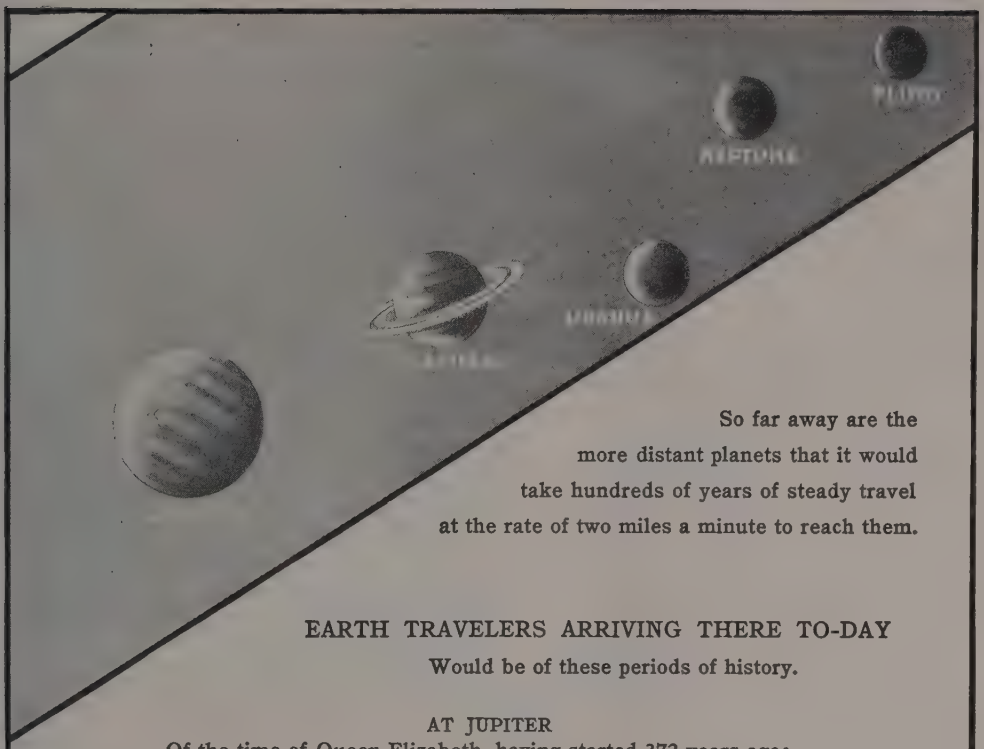
EARTH TRAVELERS WHO MIGHT BE ARRIVING TO-DAY

How they would have looked and dressed, if they had started days or years ago to travel to the Moon, the Sun, and the nearer planets, and had journeyed steadily at a rate of 2 miles a minute. To arrive at the Moon to-day, this boy started 83 days ago; at Venus, 25 years ago; at Mars, 46½ years ago; at Mercury, 54 years ago; at the Sun, 88½ years ago.



A LIFE-TIME TRIP

All these people might have lived within the life-time of an old man. The modern boy, the youth of a generation ago, the whiskered man and his older brother, both of the later 19th century, and the old man who started long before the Civil War.



So far away are the
more distant planets that it would
take hundreds of years of steady travel
at the rate of two miles a minute to reach them.

EARTH TRAVELERS ARRIVING THERE TO-DAY

Would be of these periods of history.

AT JUPITER
Of the time of Queen Elizabeth, having started 372 years ago;

AT SATURN
Of the time of Chivalry and the Crusades, having started 755 years ago;

AT URANUS
Of the days of the later Roman Empire, 1610 years ago;

AT NEPTUNE
Of the days of Egyptian civilization, 2571 years ago;

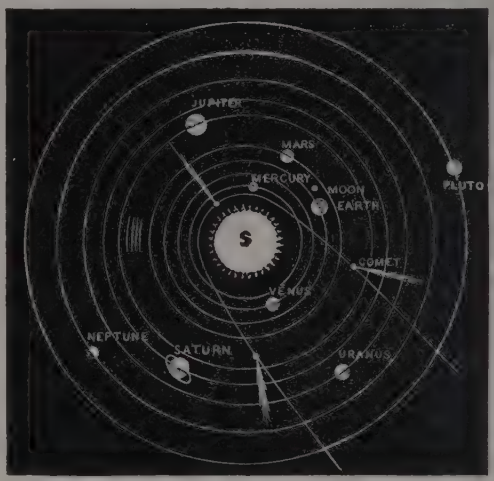
AT PLUTO
Of the days of Prehistoric Man, 3333 years ago.

the sun as the one inside it. Of the inner group, Earth is the largest, Mercury and Mars are much smaller, Venus nearly equals the Earth in size. All of the outer planets, with the exception of Pluto, are giants compared with Earth. Uranus and Neptune measure over 30,000 miles through, while our diameter is, you remember, only 8000 miles; and Jupiter and Saturn are giants compared with them, having diameters of 89,000 and 76,000 miles. These are figures too big for us to think about even in trying to imagine worlds, but we can get from the picture a little idea what a tiny dot our great earth is when it is compared to these huge worlds. All this helps us, too, to understand how wonderful the sun is, for all these huge planets are small compared with the sun. If the sun were a hollow ball and all the nine planets were tipped into it, they would fill only $\frac{1}{660}$ of its space.

PLANET RACERS

Another interesting thing about the planets is their speed. This grows less as we go out in the circle. Mercury is so near the sun, and is therefore so strongly pulled by it, that it has to travel very fast, or it would be pulled into it and be burned up. It travels along at a rate of thirty miles a second. Venus goes at twenty-two miles a second, Earth at nineteen, and Mars at fifteen. But Jupiter and the other outer planets are far enough away from the sun to go along at a much more leisurely rate, Jupiter going at eight miles a second, Saturn at six, Uranus at four, and Neptune at only three. Let us see if we can get a clearer idea how fast that is. Chicago is a thousand miles from New York. At the rate Mercury travels, or thirty miles a second, it would take a train only about thirty-three seconds to go from New York to Chicago. At the rate of our Earth, an airplane would fly to Chicago in a minute, with several seconds to alight. Our Earth is traveling nineteen miles a second, or 1140 miles a minute, or 68,400 miles an hour. At that rate one could go around our world from New York to New York again in twenty-five minutes, with something to spare for delay.

This speed decides the length of their years, for our year is the length of time which it takes us to travel round the sun. Mercury rushes along so fast that it gets round in 88 days, and so has four years to our one on Earth; Venus has 225 days in its year; Earth 365, and Mars 687, while Uranus only gets round the sun once in 84 of our years, and it actually takes Neptune $164\frac{3}{4}$ of our years to pace out its remote and immense course.



THE SUN AND ITS PLANETS

MERCURY AND VENUS

Mercury is so small and keeps so near to the sun that he is very hard to see from Earth. Indeed, from some parts of the globe he is almost never seen. He gets his name from his great speed, for Mercury was in the Greek mythology the messenger of the gods, darting swiftly along on their errands. He is not such a tiny messenger, however, for he is a good deal larger than our moon.

Everyone must have noticed Venus, our beautiful evening star, which shines like a little silver lamp close to the sun at sunset. There is no star in all the sky that shines so brightly as Venus does when she is at her brightest. It is a curious fact that some planets shine much more brightly than others, without regard to their size — that is to say, the surface on which the sun's rays strike is of greater reflecting power in some than in others. One of the brightest things in Nature that we can imagine is a bank of snow in sunlight; it is so dazzling

VENUS, THE EVENING STAR

As seen through the telescope, the lighted portion of Venus changes its shape like the moon.

that we have to look away or wink hard at the sight; and the reflecting power of the surface of Venus is as dazzling as if she were made of snow. This is probably because the light strikes on the upper surface of the clouds which surround her. In great contrast to this is the surface of Mercury, which reflects as dully as a mass of lead. Our own moon, although appearing quite bright when at her best, has not a high reflecting power, as compared with a brilliant planet like Venus.

THE "SILVER LINING"

Why is Venus so bright? Probably because she is always wrapped in thick clouds. You know the old proverb, "Every cloud has a silver lining"; but did you ever think what it means? It means that those days when our sky is all covered with dark clouds and we have to spend our time indoors because of the rain are the days when our world is shining far more brightly to the other worlds than on our bright, cloudless days. For all the planets, and our own world like the rest, shine by the sunlight which they throw back from their surfaces. And when we have dull, cloudy days, the light that does n't get through the clouds is nearly all thrown back from the outer side of them, so that they shine to the other worlds almost as white as newly fallen snow. If the whole world were wrapped up in a great dark cloud, it would look from the outside just like a huge ball of snow. When we look at Venus we see simply the "silver lining" of her clouds.

So far as size goes, you might call Venus the twin sister of Earth. She is only a little smaller than our world, and she comes nearer to us than any of the other worlds of our family.

As she goes round the sun in a circle inside our earth's orbit, she appears first on one side of the sun and then on the other, and so is seen as an evening or as a morning star in turn. And because she is between us and the sun she shows what astronomers call "phases" — that is to say, she changes like the moon, and is sometimes round and full, sometimes like a half-moon, and sometimes just a thin slip of light, like the new moon. There are few things in the heavens so beautiful as Venus when she appears like a crescent moon.

MARS, THE RED PLANET

Sometimes you will see in the sky a star which is distinctly reddish in color. This is the planet Mars, named because of his blood-color for the Roman war-god Mars. Once in every fifteen years this planet becomes very brilliant in the midnight sky. Rising in the east at sunset, it climbs steadily higher and higher — a great red splendor that rivals Sirius and the giant Jupiter himself. It is little wonder that by many folk its appearance was taken as an evil sign, nor that it always frightened ignorant people. It seemed hardly possible to them that so red and fiery a light should appear without being a sign that war and trouble were to follow on earth.

Mars is the most interesting to us of all the planets because he is most like us. At times in his journey around the sun he comes much nearer to the earth than at other times. At such times, astronomers study him carefully. Since this planet has very few or no clouds, the surface can be seen. Then, too, Mars turns on his axis in such a way that all parts of Mars can be seen from the earth.

DO PEOPLE LIVE ON MARS?

Mars has days and nights as we do. Its day is only half an hour longer than ours. While Mercury and Venus turn themselves about so slowly in their path round the sun that it takes each the whole length of one of its own years to turn completely round, Mars spins round in a day much as we do; so instead of one face being towards the sun for nearly half its year and the other turned away, as in the case of Mercury and Venus, all parts of Mars have their turn of the sun's light and heat once in a day and night like ours. Then Mars, too, has a north and a south pole, and its tip towards the sun is so much like ours that its seasons must be very like those we have. Also, Mars has an atmosphere, a blanket of air surrounding it. This air is probably very thin, since Mars has not enough gravity to hold a large atmosphere. Its atmosphere is probably as thin as the air that is found on the tops of our high mountains. In 1877 it was found out that Mars has two moons, traveling round it. One travels so fast that it goes round Mars three times each day.

Because Mars is so like us in all these ways, there has been, especially in the last few years, a great deal of discussion as to whether there could be people, not like us, but some sort of people, living on Mars. One man in particular, the late Professor Percival Lowell, thought this was possible if not even probable. Most astronomers think it unlikely. But it is an interesting idea to think about, and makes everyone want to find out all he can about Mars.

MARS THROUGH A TELESCOPE

When you see him in the telescope, the bright red star that you saw with the naked eye expands into a broad red globe of a fiery orange color. At the poles this globe is capped with patches of brilliant white, which stand out very brightly on the reddish ground that surrounds them; and the red surface is marked all over with patches and streaks of a darker color which are generally of a sort of greenish-blue.

Look at the map of Mars, in which the surface appears to be cut up into land and water,

MARS AND HIS CANALS

continents and oceans. The men who first observed Mars with accuracy saw that some parts were of a reddish color and others greenish, and arguing from our own world, they called the greenish parts seas and the reddish, land. Maps were made in which these seas were named after some of the famous astronomers of our world. For a long while no one doubted that we actually looked on a world like our own, more especially as there was supposed to be a covering of atmosphere. The so-called land and water were much more cut up and mixed together than ours, it is true. The red color of the part they named land puzzled astronomers a good deal, for our land seen at the same distance would not appear so red, and they came at last to the conclusion that vegetation on Mars must be red instead of green! But after a while another disturbing fact turned up to upset their theories, and that was that they thought they saw "canals," or what they called canals, on Mars.

THE CANALS OF MARS

A great Italian observer, about half a century ago, startled everybody by saying that he had discovered that the whole of the Red Planet was streaked over with a network of long, thin, dark lines. Some people could not

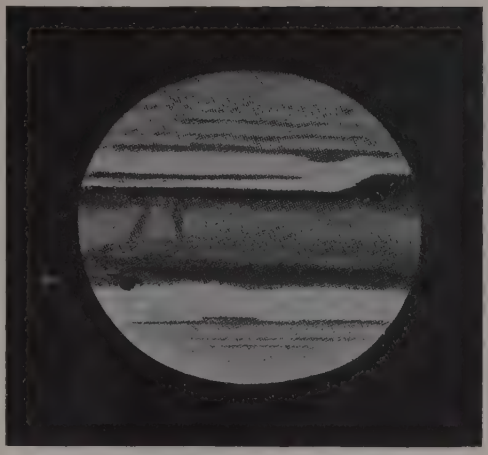
see these lines at all, but many could, after they had once been found; and ever since then more and more have been discovered, until the map of Mars is quite covered with them.

These straight lines are called "the canals of Mars." "Canals" is not a very good name for them, because, when we talk of a canal, we mean a great ditch, dug by human beings between two seas or two rivers, and filled with water so as to make a waterway; and no one really knows if the canals of Mars are like that, or, indeed, what they are at all. If they are cuts in the surface of the planet like canals, they are of great width and depth. The narrowest of them would measure 50 miles in width, and the widest nearly 200 miles, while some of them would be 3000 miles long.

Most interesting in its bearing on the question of the possibility of vegetation and of life on the planet is the study of the temperatures on the planet, which has been carried on with great care and thoroughness at two observatories. These would seem to indicate that near the middle of the Martian day the temperature at the equator, where the most benefit from the sun's rays is being obtained, ranges from 45 to 65 degrees Fahrenheit. These results run high enough above the freezing point to allow for some sort of vegetation. Near the polar caps, however, the temperatures run extremely low. These polar caps may, according to some astronomers, be great frozen seas of carbon dioxide.

The idea of possible vegetation is supported by one fact. As soon as the white cap at the pole of Mars begins to grow smaller, as if it were melting like snow, the dark lines of the canals nearest to it begin to grow darker. Some astronomers think that the dark regions grow larger and deeper in hue as the polar caps wane and the so-called spring season on Mars advances. In the same way the dark markings on the opposite hemisphere grow less conspicuous, seeming to fade away as autumn is presumably changing into winter. The very fact that there are these seasonal changes seems to imply some sort of vegetation. If there can be one kind of life, other types are possible.

You must remember that this is more or less fancy, for we really know very little about these strange appearances. Many skilled observers



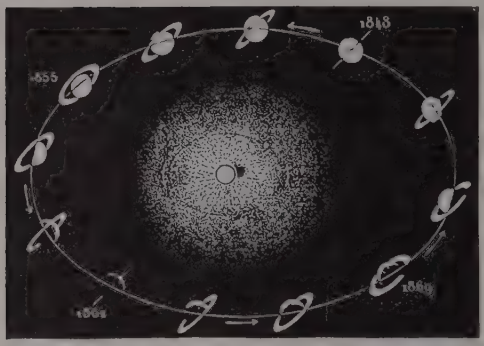
JUPITER, THE LORDLY PLANET

with exceptionally good telescopes and under favorable conditions are unable to see any canals at all. Every two years, as Mars sweeps round outside our world, he comes into a position where we can see him well. Whenever that happens, astronomers all over the world watch him eagerly, and try to find out more about him; and we may hope that, since so much has been learned already, we may before long come to understand yet more about this wonderful little world.

JUPITER, THE GIANT PLANET

Outside the path of Mars lies that of the planet Jupiter, or the "Giant planet." Jupiter is the biggest planet of our sun family, and is more than thirteen hundred times as large as our earth. Perhaps the most interesting thing about Jupiter is his moons. While the earth has only one moon, and Mars two, Jupiter has nine. It would be indeed a beautiful sight to see nine moons in the sky at one time, but Jupiter is even farther away from us than Mars, and five of his moons are very tiny and thus difficult to see. The other four are large, however, and can be well seen with even a small telescope. Just as the moon travels round the earth, so Jupiter's moons travel round him, and through a telescope we can see them slowly moving.

Galileo, who lived in Italy in the sixteenth



PHASES OF SATURN'S RINGS

Why the rings of Saturn seem to change their shape.

and seventeenth centuries, was the first man to turn a telescope to the heavens. He turned it one night to Jupiter, and there he saw the wonderful sight of the moons traveling round the great planet. Now Galileo had been trying to make people believe that the earth was not the center of all things, but that it and other worlds traveled round the sun; but although it was sixty-five years since Copernicus had put forth this theory, people had not come to believe it. When Galileo began to study the heavens with a telescope and saw Jupiter and his moons, he said at once, "This is the way the earth travels round the sun." So he told the people about this wonderful sight he had seen. They would not believe him, so he asked them to come and look for themselves. They looked and saw what he had seen, and then they said that Galileo had bewitched the telescope or their eyes. At last, however, other learned men took up the subject, and the sight of Jupiter with his moons traveling round him helped to prove that the earth and other worlds were really traveling round the sun. Later in life Galileo was cast into prison and made to deny that he believed the earth traveled round the sun and compelled to promise not to teach such a doctrine.

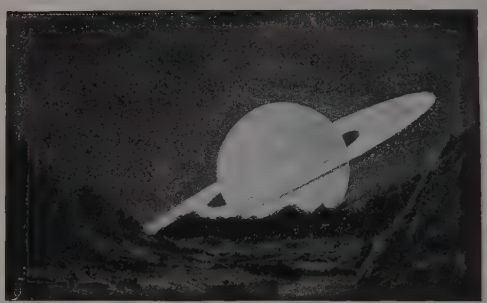
THE WORLD WITH THE GOLDEN RINGS

When Galileo turned his telescope on Saturn, which is the next world beyond Jupiter, he could scarcely believe his eyes, for instead of one globe he seemed to see three. He never found out what made this curious effect, but we know that it was what we call the "rings" of Saturn.

Saturn with his rings is one of the most beautiful objects that we can ever see in the heavens. Round and round the bright central globe circle a beautiful series of rings, dark and light, such as you see in the picture. It was a complete mystery to the people of the Middle Ages how a planet could be surrounded by rings which had no means of support, for it is plain that they do not touch the planet at any spot. It has been lately shown, however, that Saturn's rings are made up of multitudes of little moons or planets, each of which is traveling in its own path around the planet, just as the larger moons of Jupiter, or its own nine large moons, do.

There are three of these rings, lying one within the other, and separated by a fine line from each other. The middle one is much the broadest — probably about ten thousand miles in width — and the inner one, which is also the darkest, was not discovered until the year 1850.

As the planet swings in his orbit he tilts himself differently at different times, and so at one time we are looking at the rings almost from above, at another time we appear to be looking at them when they have turned a little farther upwards, and again we see them exactly edgewise. Then even in the largest telescope they are only like a streak of light, and this shows that they cannot be more than fifty or sixty miles in thickness. The one which is nearest to Saturn's surface does not approach him within ten thousand miles.



SATURN AS THE PLANET MIGHT APPEAR FROM ONE OF HIS MOONS

THE MOST WONDERFUL CREATION IN THE VISIBLE UNIVERSE

Saturn and his rings of flying myriads of small particles, attended by his eight largest satellites. This beautiful planet is composed of such light material that it would float like oak on water. Saturn is nine times greater in diameter than the Earth. The rings are composed of nothing more than a flight of myriads of small particles round their primary, the inner ones revolving once in 5 hours 50 minutes, the outer ones in 10 hours.

Keystone

PLUTO, THE NINTH PLANET, DISCOVERED MARCH 12, 1930

The two white arrows point to the little flash of light which represents Pluto on the photographic plate. The bright star showing the crossed lines of light was used as a guide in locating the planet.

TWO LONELY WORLDS

All the worlds that we have now read about were known to star-gazers as far back as the time when people began to know anything about the world; but no one ever suspected that there were any more worlds in the sun's family until the night of March 13, 1781. At that time there lived in England a Hanoverian musician named William Herschel, who was organist of the Octagon Chapel at Bath. He was very fond of astronomy, and when his musical work was done, he used to come home and get out his homemade telescope and scan the starry sky. On this night of March 13, as he was looking at the stars, his attention was caught by one small star which seemed a little different from the others.

This proved to be the planet, named by him Uranus, for the father of Saturn, which had been observed no less than nineteen times before, but never until he studied it had been recognized as a planet. This was in 1781. Something in the movements of Uranus made astronomers think that there was another planet outside it, pulling it out of its natural path. Leverrier, a French astronomer, computed where such a planet should be, and in 1846 wrote Galle, a German astronomer, to direct his telescope to a certain part of the sky, and he would find a new planet. Within half an hour after beginning to look, Galle found the planet called Neptune.

THE MOUNT WILSON SOLAR OBSERVATORY, CALIFORNIA

PLUTO — THE NINTH PLANET

On March 12, 1930, the Lowell Observatory announced the discovery of a ninth planet. It is four thousand million miles from the sun. It is out so far that it is thought that it would require two hundred and sixty years for the planet to go once around the sun. That would mean that if one lived on this planet, one would only have one birthday in almost three of our centuries. It has been named Pluto, for the Greek god.

It will take many years of study before we shall know a great deal about this new planet. (That is why it is not recorded in the table of statistics.) We must remember the new planet is as old as our own earth and has been away out there beyond Neptune ever since the solar system was born. It is called a new planet because it has recently been discovered by the astronomers. Its discovery is a sign of the exactness of mathematical calculations in astronomy. Because of certain slight variations in the measurements of the path of its nearest planet-neighbor, its presence was predicted twenty-five years before its discovery.

STRANGE SIGHTS IN THE HEAVENS

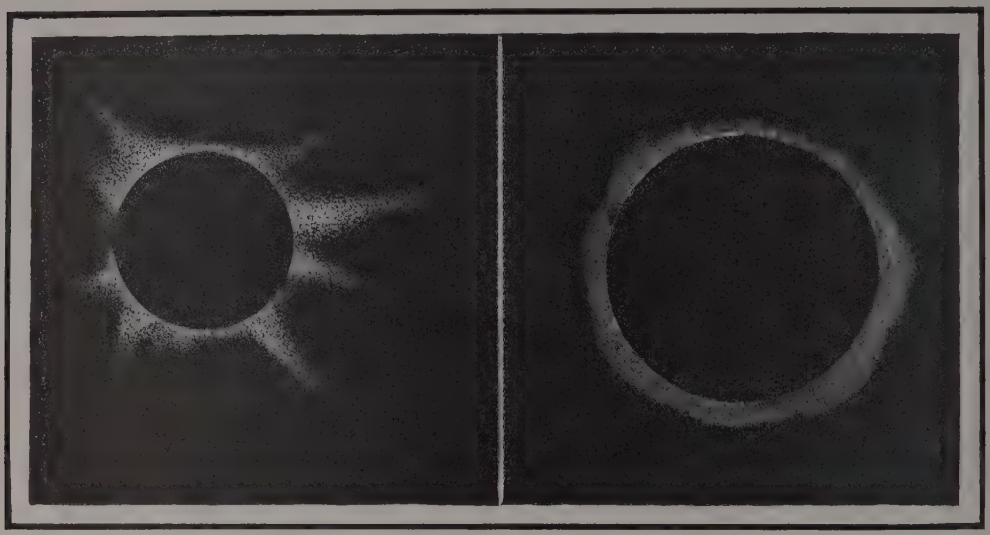
SHADOWS OF WORLDS

SHADOWS make all sorts of queer effects. You know yourself how you can make animal shadows on the wall from your fingers, and how, as you walk along, your shadow will grow tall and then short again and take all kinds of strange shapes. If you saw some of these shadows without knowing what made them you would think they were very queer people and animals living on the earth, and you would not know how to explain them at all. That is just what happened in the old days when there were eclipses. *Eclipse* comes from the Greek word *to fail*. When there is an eclipse, the light fails. Sometimes it fails because the moon gets between the earth and the sun, and the sun is almost wholly covered. We call that a sun or solar eclipse. More often the earth gets between the sun and moon, so that it throws its shadow on the moon, and that is an eclipse of the moon. Our astronomers can predict from what they know of the movement

TABLE OF STATISTICS OF THE MEMBERS OF THE SOLAR SYSTEM

Name and Sign of the Planets	Distance from Sun in Millions of Miles	Time of Revolution round the Sun	Equatorial Diameter in Miles	Mean Speed of Revolution per Second	Mass in Proportion to the Earth (Earth = 1)	Number of Satellites
Mercury ☿	36	About 88 days	2,993	$29\frac{3}{4}$ miles	0.05	0
Venus ♀	67	" 225 "	7,438	$21\frac{3}{4}$ "	0.81	0
Earth ♁	93	" 365 "	7,926	$18\frac{1}{2}$ "	1.00	1
Mars ♂	142	" 1 year 322 "	4,191	15 "	0.11	2
Asteroids ②	136 to 490	" $1\frac{3}{4}$ to 12 years	1 to 478	8 to 15 "	—	—
Jupiter ♃	484	" 11 years 315 days	89,330	8 "	314.5	8
Saturn ♄	887	" 29 " 167 "	75,811	6 "	94.1	10
Uranus ♅	1,785	" 84 " 7 "	36,787	$4\frac{1}{4}$ "	14.4	4
Neptune ♆	2,796	" 164 " 284 "	31,071	$3\frac{1}{2}$ "	17.0	1

	Distance from the Earth	Revolution round the Earth	Diameter	Mass in Proportion to the Earth (Earth = 1)
Sun ☉	93 million miles	———	864,000 miles	329,000
Moon ☽	238,851 miles	27 days 7 hrs. $43\frac{1}{6}$ min.	2,160 "	0.0124



HOW THE SUN LOOKS IN A TOTAL ECLIPSE

The left-hand cut shows the rays of the sun's corona. The right-hand cut shows another form of the corona at a different eclipse.

of the heavenly bodies just when these eclipses are going to happen; they tell us beforehand; and we, because we know what is coming, are very much interested and not at all frightened when the sun or moon is darkened for a time, and all kinds of strange light effects are produced in the sky. But the early peoples were very much frightened when these strange things happened, and they made up wonder stories to explain how such marvelous and dreadful events could take place.

It is no wonder that people are frightened by the solar eclipses, for they are truly awe-inspiring. All nature is affected by them; the cattle grow restless during a long eclipse, and dogs set up long howls. A pale, mysterious light makes everything look ghastly. The sun looks like a black face, and the stars shine out as in the night-time. Only when the first sunbeam escapes from the edge of the moon does the mystery vanish, and we breathe freely again.

Early and uncivilized peoples believed that a mighty dragon was trying to swallow the sun. If he succeeded, the end of the world would come. So they made every effort, in the midst of their own terror, to try to frighten him away. To this day vast numbers of Chinese run out into the street at the first sign of an eclipse — of which for hundreds of years they have been carefully warned by astronomers — and set up a terrific din with drums, whistles, trumpets, sticks, and yells, to scare away the monster, and force him to give back the victim which has just disappeared between his huge jaws.

STORIES OF ECLIPSES

Though they did not understand what made them, astronomers learned very early in star-study to reckon on the times of eclipses and to let people know when they were going to happen. This was part of the business of the court astronomers in China, more than four thousand years ago, and there is a story in a very old Chinese book telling about two astronomers, named Hi and Ho, who lived more than two thousand years before Christ. It was their duty to keep track of the movements of the stars and inform the people when events like these were going to happen. But they lived merrily and well at the court, and forgot the duties of their office, giving no heed to the course of the stars and thereby getting the whole court into a confusion about the

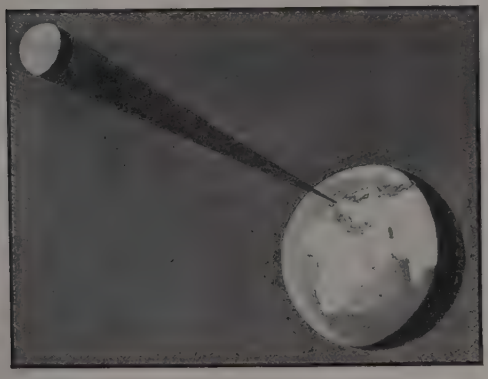
reckoning of time. All at once, as fate would have it, they were overtaken by an eclipse of the sun. No one had been warned, and there was the greatest terror throughout the whole of China. When the eclipse was over, and the terror had subsided, the two unlucky astronomers were brought before the emperor and beheaded.

HOW COLUMBUS GOT HIS SUPPER

An eclipse aided Columbus on the island of Jamaica soon after he discovered America. The savages had taken him and his companions prisoners, and would give them no food. By his reckonings he knew that an eclipse of the moon was coming. He called the chiefs to him and told them that if they did not bring him and his companions food that very night he would take from them the light of the moon. At first they laughed at him; but when the dark shadow began to creep over the face of the moon they ran to him with all the food they could lay hands on, beseeching him to forgive them and to order the moon to shed its light again. This happened on the 1st of March, 1504, a date by which according to modern tables of eclipses there should have been an eclipse. So it helps us to check up the date.

SOLAR ECLIPSES

Eclipses of the sun take place when the moon comes in between the earth and the sun, thus cutting off more or less of the sunlight. Eclipses are of two kinds, — partial, where only part of the light of the sun or moon is cut off, and total, where all the light is cut off. Though we may hope to see many partial eclipses of the sun, it is not often that we can see total eclipses in this country, as they are more often only visible in countries nearer the equator. A total eclipse is a very beautiful sight, and astronomers will willingly travel to far-off parts of the earth in order to see one.



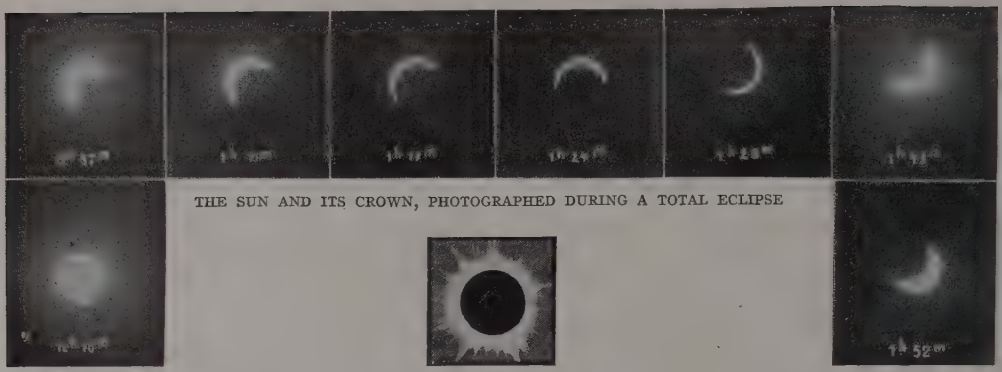
WHEN THE MOON GETS BETWEEN THE SUN AND THE EARTH WE HAVE A SOLAR ECLIPSE

COLUMBUS AND THE MOON'S ECLIPSE

When a total eclipse of the sun takes place, the moon comes in exactly between the sun and the earth, cutting off all the sun's light for a few minutes. The time during which the sun is quite hidden is very short indeed — never quite eight minutes, and generally a good deal less. In that little time, however, a great deal can be seen.

When the moon comes between us and the bright globe of the sun, we see that a little bit of the sun is hidden, as if something were taking a bite out of the circle of light. Then gradually the dark "bite" grows bigger, and the daylight begins to fade. At last the moon gets right between us and the sun, and the last little streak of sunlight is blotted out. And then, in a moment, a most wonderful sight flashes before our eyes.

Now you see a big, round, dark globe where the sun was shining a little while ago. This globe looks as if it were made of black velvet — the globe of the moon which has just hidden the sun. But all around it there streams out on every side the most beautiful light. It is of a pearly white color, and shoots out here and there



THE SUN AND ITS CROWN, PHOTOGRAPHED DURING A TOTAL ECLIPSE

in great streams of light, some of them stretching out hundreds of thousands of miles from the sun. These beams grow fainter the farther they get from the sun, but close in to the edge they are all mingled together in a ring of dazzling brightness.

Nor is that all. The color of the glory changes at the very edge, and there is a perfect circle of brilliant crimson light running around the margin of the dark moon. This circle of light is very narrow but very bright; and here and there a great jet of crimson gas shoots out from the circle, and soars up for thousands, or even for hundreds of thousands, of miles, showing beautifully against the pearly background. These things can be seen for only a very few minutes, for the moon is always moving onward. Soon the crimson flames on the one side begin to fade in the growing light, and those on the other side begin to get covered up by the advancing moon. Then, all of a sudden, there is a blinding flood of light as the edge of the sun appears again from behind the moon, and the eclipse is over.

But you have seen the sun's crown, or *corona*, the beautiful halo of soft pearly light which is always round the sun, but is usually shut off from our view by the dazzling sunlight; and you have seen the flames of hot gas, which will help you to believe that the sun is a great ball within which the storms that make the sun spots are continually raging. These huge torrents of flame are rushing up from beneath the sun's surface. Every now and then there will come a great outburst; but always red flames and streams of crimson fire, 100,000 or 200,000 miles long, are being thrown out.

HOW OFTEN DO ECLIPSES COME?

The least possible number of eclipses in a year is *two*, both of the sun; the largest, *seven*, five solar and two moon (or lunar), or four solar and three lunar. The most usual number is four. In a year it is possible to have three lunar eclipses. This happened in 1852 and 1898, and again in 1917. With four solar eclipses, this made, in 1917, the highest number possible. Taking the whole earth into account, solar eclipses are more frequent than lunar. This is not so, however, at any given place. A solar eclipse can be seen from only a small part of the globe, while a lunar eclipse is visible over considerably more than half the earth. Solar eclipses that are total somewhere or other on the earth's surface are not very rare; but at any given place the case is very different. Since the track of a solar eclipse is a very narrow path over the earth's surface, averaging only sixty or seventy miles in width, we find that in the long run a total eclipse happens at any given place only once in about 360 years. During the nineteenth century seven shadow tracks crossed the United States, and there will be the same number in the twentieth. Besides the one in 1932, total eclipses of the sun will be visible at some point in the United States in 1945, 1954, 1970, and 1979.

COMETS — THE GREAT TRAVELERS OF THE SKY

Comets are very strange and beautiful sights. The word "comet" comes from a Latin word meaning "long-haired," and when seen at night

a comet certainly does look like a long silvery hair, hanging against the dark sky. We talk of this hair as the comet's tail, for it stretches out from the bright head, which is the real comet, streaming far behind it across the sky, sometimes straight, and again twisting and curling as smoke from a chimney does on a windy day.

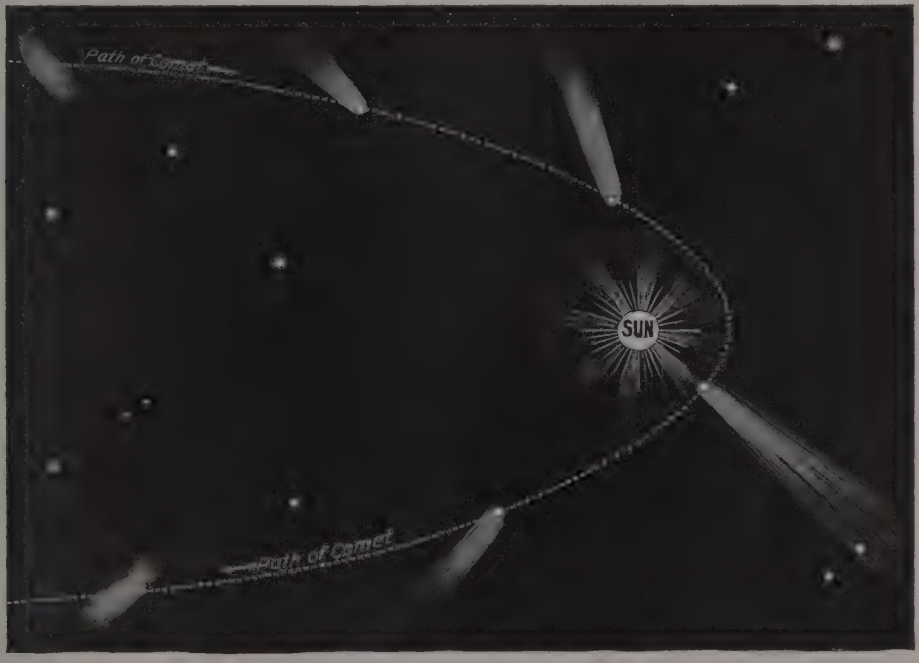
That is our idea of a comet. But there are comets of all sorts and sizes. Most of them can never be seen with the naked eye at all. They are faint, little, fuzzy balls of light, which come drifting in towards the sun, sometimes shooting out a faint tail as they come near him, sometimes scarcely managing to make a tail at all, and never getting very bright. Then, when they have passed round the sun, they gradually drift away from him, losing most of the little light they had, and are soon lost to sight.

In the picture below the path of a comet in its relation to the sun is shown, and we can see why it sometimes seems to travel with its tail first.

DO COMETS RETURN?

A great comet is so big that it is difficult for us really to get an idea of its size. The January comet of 1910 had a tail that reached for more than 100,000,000 miles across the sky. If its head had touched the sun, its tail would have reached right across to our world, and the end would have waved 7,000,000 miles beyond us. And there have been comets with tails far longer than that.

What do we know about comets? We have learned, through the studies of astronomers, that they are not, as men of old thought them, "balls of fire hung in the sky by an angry God," to give sign of some coming misfortune. But what are these strange and mysterious visitors? Many of them, possibly all, are members of another family belonging to the sun. They start from the sun; they travel, each one on a path of its own, which is much more irregular than those of the planets; and that path, how-



THE OUTWARD PRESSURE OF THE SUN

When a comet is far from the sun it appears a shapeless patch of light, but as it approaches it develops a streaming tail of light that looks as if it were blown away from the sun, owing to the tearing force of the light of the sun. The comet approaches the sun with its head toward the sun. It seems to back away from the sun after it has gone around. It leaves with its long tail going first.

Photographed by Rev. Joel H. Metcalf

MOREHOUSE'S COMET

The telescope was made to follow the motion of the comet. Hence, the stars show trails, which indicate how much the comet moved during the exposure of 70 minutes.

ever far away it may go, leads them back to the sun. Comets which do this always make the journey in a fixed length of time, just as planets do. So astronomers now can tell when certain comets are due as certainly as you can tell from a time-table when your train is due. But the journeys of comets are often much longer than those of planets. They vary from three and a half to over two thousand years. So comets are very wonderful pilgrims indeed. The worlds that go round our sun are called "planets," or "wanderers"; but the name might be far more truly given to the comets, for they are the real wanderers of the heavens.

HALLEY'S COMET — THE COMET OF CONQUEST

The first comet actually found to be a regular visitor to the sun was Halley's Comet, which made such a stir in the spring of 1910. In the year 1682 a fine comet was seen, and Halley, a famous English astronomer, though he saw it only once, and not very well then, was much interested in it, for this reason: that, when calculating the paths of a number of comets, he found that either this one, or else one which followed exactly the same path, had appeared three times in the two hundred years before. Soon he became sure that it was the same comet which came back every seventy-six years, and ventured to prophesy that it would return in 1759, saying, "If the comet returns in accordance with my prediction, posterity will not forget that this first prediction was made by an Englishman."

Halley died a short time before 1759; but the comet duly appeared up to time, and rounded the sun within a month of the date predicted. It came back again in 1835, this time coming within a few days of the time-table which had been drawn up; and in 1910 the time-table proved more accurate still.

But we know now that this wonderful wanderer was not making its first appearance at the time to which Halley traced it back. It has been followed for century after century,

and records of its appearance have been found which go as far back as 240 B. C. Of course, it may have been coming and going for long before that. But at least for more than two thousand years this strange visitor has been traveling through space, coming up to our sun every seventy-six years or so, and then wandering away again into the darkness, growing dimmer and smaller as it goes, till it is lost to sight once more.

We are all very much interested in one of its returns. In 1066, when William of Normandy was getting ready to invade England, a wonderful bright star appeared in the sky. When the people of Britain saw the great comet in the sky they were very much afraid. The people of Normandy were frightened, too, but William himself was not afraid of the comet, telling his soldiers that it was a sign that a kingdom wanted a king. After the Battle of Hastings everybody believed that it had been the herald of William's victory and Harold's overthrow. So, when the Bayeux Tapestry was worked, which tells in needlework the whole story of the Conquest, the flaming star was pictured on it — a wonderful thing, with a head of red and blue, and fiery streamers of different colors, while people stand below pointing to it, and the words are written beside it in Latin: "These are wondering at the star." Now we know that this terrible star of the Conquest was one of the returns of Halley's Comet.

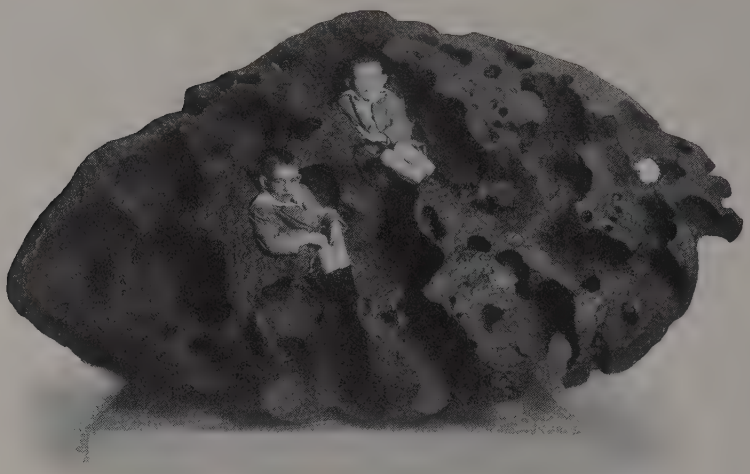
WHAT IS A COMET?

What do you suppose a comet really is? Well, if we could get near enough to one to see how it is actually made, and what happens to it, we should probably see something like this: The head of the comet, which looks like a bright star, would really be like a great swarm of bees; only the bees would be things something like pebbles, and while they all traveled along together, there would be wide spaces between them. When it was far away from the sun, the comet would be nothing but this swarm of pebbles, and would look quite dull and faint. Then, as it came nearer, it would begin to glow and get brighter; and then, in some way that nobody quite understands, the sun would begin to exert a powerful influence upon it, and the swarm would throw up great jets of starry mist, which would stream away behind it, just as the smoke of a steamer is driven back by the wind. If we could follow our comet century after century, we should see it gradually wasting away, and perhaps splitting up into two or three little comets. And by and by it would vanish, and never be seen again at all — at least, not as a comet.

But it would still leave something behind it to remind us of it. You have seen a shooting star flashing across the sky at night, like a bright streak of light. Well, sometimes these shooting stars, instead of coming singly, come in showers. About November 14th of every year there is a shower which sometimes sends us hundreds of these bright visitors in a single night. It may be that this shower is all that is left of a comet that came several times round the sun and was last seen, split up into two, about the middle of the last century.

SHOOTING STARS

This is probably what happens to all comets in the end. The great swarm that makes up the head gets gradually scattered out along the path in which it travels, till at last we cannot see it any longer as a single mass. It is just a long string of pebbles, stretching for millions of miles, perhaps, along its old track. But when our earth, as it rolls along through space, crosses the path where these pieces of the old, worn-out comet are traveling, they rush down with tremendous velocity through our air, getting hotter and hotter as they rub against it, until at last they are quite burnt out. And so a shooting star is just one of the pieces of what may once have been a great and wonderful comet. Now there are some shooting stars which do not seem to have ever belonged to any comet. The big ones that come singly, and that sometimes fall down upon the earth, still quite hot from their rush through the air, seem to travel through space on their own account, and nobody can tell where they came from at the first. But the great showers where hundreds of little shooting stars are to be seen darting across the sky, and all getting burnt out before they reach the earth, are all relics of old comets that have been wandering for no one knows how long.



Courtesy of American Museum of Natural History

THE WILLIAMETTE METEORITE, FOUND BY PEARY, IN GREENLAND

It has been suggested by some astronomers that meteors may have come from away out in space. Others suggest that they really represent material that was pulled out of the sun when the solar system was formed. The meteors, like bricks and lumber left after a building was built, have been drifting in space ever since the earth was formed, until they have traveled too near the earth. The earth's gravity has then pulled them to the earth. There are great belts of these meteors about the sun, and whenever the earth passes through one of these belts, we have a shower of meteorites.

Astronomers have found that as many as 100,000 meteors enter the earth's atmosphere every hour or about two and a half millions a day. Of course, all of these are heated to white-hot temperature because of the friction of the air. Most of them waste away, leaving behind them trains of lighted material. This material becomes dust in the air.

The atmosphere, we might say, grinds up the meteors in such a way that they fall as harmless dust. Very few of the millions of meteors which enter the earth's atmosphere are large enough, after they have been heated in the earth's atmosphere, to do any damage when they strike the solid part of the earth. We need not worry about being hit by a shooting star.

STARS THAT FALL FROM THE SKIES

On the writing table of King Edward VII there stood, besides other costly objects, a plain piece of rock, a rough, unhewn stone about the size of a man's fist. "What a queer letter-weight for a king!" And yet in its way this letter-weight was a costly article. Infinite trouble, terrible dangers, and much science combined to place the stone on the monarch's desk. The leader of the Himalayan Exploration Commission chipped it off at the highest point reached on the mountain to which he gave his name — Everest — to hand it to his sovereign as a symbol of the conquest of the highest point on earth.

"But, if the king could boast of having the highest point of the earth on his writing table," says a German astronomer, "I feel inclined to boast of a stone coming from much loftier realms than even the highest earth-mountain. I own a black, insignificant pebble, which might easily be taken for a bit of coal, and which by rights should find its place in the ash barrel instead of being mounted in gold as a scarf-pin.

"The tiny stone hails from regions never yet penetrated by man; its home is not found on high mountains, nor in ocean deeps, nor in dense jungles, nor in the interior of the earth.

It does not belong to our planet at all. It was at one time more distant than the sun, moon, and all the planets. Perhaps millions of years ago it traversed the shining belt of the Milky Way; perhaps thousands of years ago it crossed the stars of the Great Bear, perhaps — perhaps!

"And then one fine day a radiant star appeared in its course through the voids of space and the little pebble was drawn within its circle of attraction. With ever-increasing rapidity it traveled towards that bright star we call the sun, and the nearer the pebble approached the larger the sun-star grew, until it loomed out as a huge ball of fire around which other balls revolved. Our stonelet rushed boldly on towards one of these globes; this became larger and larger, whirling clouds grew visible, then oceans and land, for it was our earth, and finally it dragged our pebble down towards it with tremendous speed. It dashed down through cloud wrappings in a white-hot glow from its swift journey, splintering into many pieces and falling on the ground in sparklets. Then people who saw its fall cried out, 'A meteor! A shooting star!' Our little stone lay at peace after a journey which may have lasted millions of years, past huge worlds which we see only as small stars. It is one of these tiny stones I wear in my scarf-pin."

Courtesy of Harvard College Observatory

STAR CLUSTER IN CENTAURUS; THE FINEST GLOBULAR CLUSTER IN THE SKY

THE STARS

THUS far we have talked about only the big letters, the capitals that go to make up the golden lettering of the great open book of the heavens. Now we can turn to the small letters, the fixed stars, whose tiny twinkling points dot the whole heavens. These are the real stars, — not planets or comets or shooting stars or moons, not even parts of the sun family, — but suns themselves so far away from us that they appear like points of light. As we study them, we shall find that they make up the pictures in our book of the heavens.

STAR GROUPS, OR CONSTELLATIONS

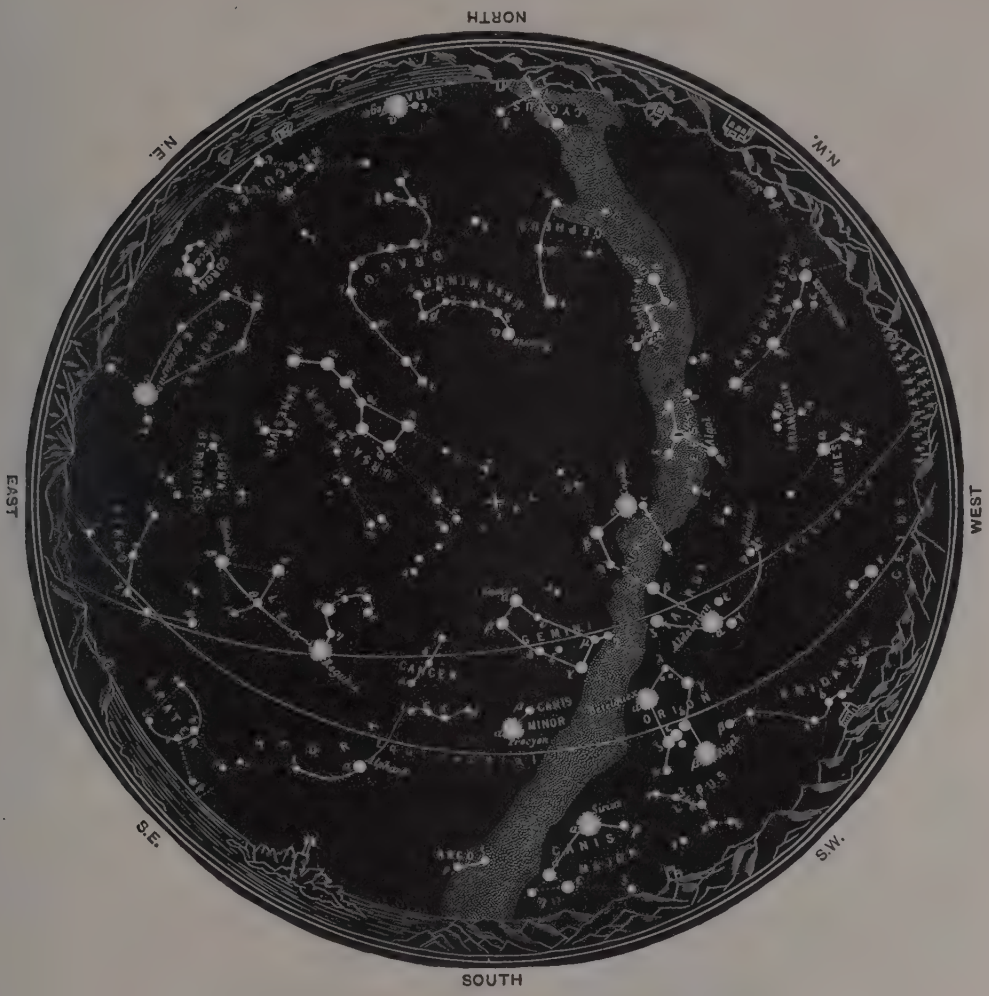
These star pictures, made by groups of stars in the sky, are always the same. They never change their shape. When we say that, we have stated the most remarkable fact that we could about them. Of course they move. They both *seem* to move, because our earth turns round, and actually *do* move on their own account, traveling hither and thither in space. But they also keep the same position with relation to each other. So that though a group — or constellation, as it is called from the Latin words *stella* for "star" and *con* for "together" — is actually moving, and shows in a new part of the heavens, yet the picture, even though it be upside down, stays the same, and has stayed the same for all the thousands of years we can know anything about.

Think a minute about what this means. There these stars stood when, thousands of years back, the cave men of the Stone Age represented the flower of mankind; and there they stood when, thirteen hundred years before Christ, Egypt's great king, Rameses II, marshaled his huge forces in war against the Syrians. Columbus saw them when he peered out anxiously for the desired land at dead of night; Napoleon saw them in the great steppes of Russia; and Nansen watched them sparkle in the ice and snow regions of the Pole, far away from all civilization. And yet we know that these stars move in large orbits with great speed; that the stars which apparently group themselves together in certain figures — constellations — are in reality divided by huge dis-

A STUDY OF THE CONSTELLATION FIGURES PICTURED BY THE ANCIENTS

tances, and that their nearness to each other is due only to an accidental perspective. Measurements have convinced us that some stars move through the universe at a speed of many thousand miles a minute; some members of a constellation may approach and recede from each other, while others wander away together through the infinite. Although this takes place at a tremendous speed, yet their distances from us are so immense that they have appeared for thousands of years in their old shape, as though the stars forming these constellations stood immovably still.

Even the names by which these star pictures are known have come down to us for thousands of years. People who studied the stars in the earliest days fancied they saw all sorts of figures among them, — figures of men and women, beasts, dragons, and ships. They named the star groups after these figures, and these names, or our English translations of them, are the names by which they are still known. Some of



THE CONSTELLATIONS AS YOU SEE THEM IN FEBRUARY AND MARCH

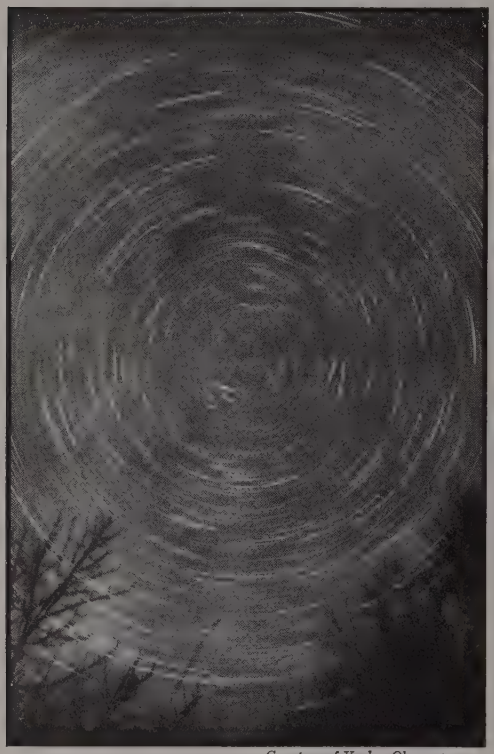
the constellations seem to us very like the names which they bear; for others it takes a pretty big imagination to see the likeness to the figures for which they are named. But the names carry us back to the time of the astronomers of ancient times, for whom each star had a special meaning; and we can always trace out the stars which make up the group. Finding them and trying to see the pictures, both the easy ones and the hard ones, is the fun of star-gazing, and nobody wants a puzzle to be always easy.

MAKING FRIENDS OF THE STARS

Every boy and girl should learn to find a few of the constellations. It is easy to do, and when you have learned the names of the bright stars, and the positions of the constellations, you will be surprised to find how interesting it becomes to look up at the sky on a clear night, for the stars seem like friends as we see them twinkling away in the heavens.

If you are to be a star-gazer, there is one

thing you must remember; that is, that the appearance of the starry heavens changes with the seasons. If the different stars were always in just the same direction from us, star-gazing would lose most of its interest. If the Great Bear or Sirius were in exactly the same place every night, we should find them once for all



Courtesy of Yerkes Observatory

CIRCUMPOLAR STAR TRAILS

and be done. Not only do the stars appear to go round the earth once in twenty-four hours, but, owing to the apparent motion of the sun, the stars appear to rise and set four minutes earlier every night. The result is a constant change, gradual but steady, in the position of the stars at any given time, and at the end of the year the entire circuit is completed and the stars return to the places which they occupied a year before. One star in the heavens, however, scarcely changes its position at all. This is the star which you must learn to find first.

THE POLE STAR

Suppose you look up at the sky on a clear night. You will see a great number of stars — so many that it is impossible to count them; and you will notice that these little stars are all moving across the sky. Stand where you can see a tall tree or a church spire against the southern sky, and watch a bright star close to it on the east side. In a few minutes the star has come to the edge of the spire; then it passes behind it, and is out of sight for awhile; and then it comes out again on the west side, and begins to move away. And all the other stars in the sky are doing exactly the same — all moving from east to west — except in one place. If you turn and look up to the sky in the north, you will see one fairly bright star which does not seem to move at all; and the stars that are quite close to it move so slowly that you can scarcely notice their motion.

All the stars in the sky seem to move in circles round this star, the ones nearest to it in small circles, and those farther away in larger circles, till you come to the ones whose circle is so big that you can see only half of it, as they rise in the east, pass right across the sky, and set in the west.

This is the Pole Star. It is directly above the North Pole, and is called "Polaris," or the "North Star." This is the star around which all the northern stars move; but when you have found it you must prove this is true by going out at night and watching it. Some things which are said in this book you have to take on faith, because you cannot go out for yourself and prove them. As a star-gazer you can and should prove every word for yourself. Watch Polaris and see if the stars above it, those higher up, do move from your right hand towards your left hand (from east to west) and those below from left to right (west to east).

THE POLE STAR AND THE BIG DIPPER

The Pole Star is usually easy to find because it is the brightest star in that part of the heavens. But if you cannot find it quickly it has two faithful friends in the heavens which will guide you quickly to it. These are two stars of the Big Dipper. Very likely you know

the Dipper already. If you don't, you can easily find it in the sky on any clear night. It has seven stars, in the shape shown in the picture, and they are always in the north somewhere. Having found the Big Dipper, you can use two

THE DIPPER CIRCLING AROUND THE POLE STAR

of its stars, the two bright ones, which make up the very front part of the Dipper, the part of the bowl away from the handle. Imagine a line drawn through these two stars, and it will always point to the Pole Star. These are the Pointers. Sometimes you will find them below the Pole Star pointing upward; or they will be above it, or off to the left or right; but as the Dipper moves round the northern sky they will always be doing their task of pointing the way to the Pole Star.

THE GREAT BEAR

The stars of the Dipper are part of a group which is also called the "Great Bear." It is harder to see a bear in them than a dipper, but perhaps you can find him from the picture. Besides the Great Bear there is, not far from it, the Little Bear, which is really very like it, only smaller and harder to find. The Pole Star is the last star in its tail; from it two small stars lead away parallel to the Great Bear, and they bring the eye to a small pair which form one side of a square just like that in the Great Bear. But the whole of the Little Bear is turned the opposite way from the Great Bear, and the tail points in the opposite direction. This is also called the "Little Dipper." Perhaps you can find it more easily if you know that the handle of the Big Dipper is bent *back*, while the handle of the Little Dipper is bent *in*.

STARS TO TEST YOUR EYESIGHT

Study out the Great Bear, or, if you find the Big Dipper part of this constellation easier, look just above the second star from the end in the handle of the Dipper, and see if you can find a fairly bright star and near it a smaller one. The bright star is Mizar, while the small companion star is Alcor. Some people say they make part of the Great Bear's tail. They have Arab names, and the story is that the Arabs used these two stars as a test for eyesight, and any Arab who could not see Mizar and Alcor was not allowed to serve as a soldier. Find them first with an opera glass, if you do not place them at once; then look with the naked eye and see whether the Arabs would have taken you as a soldier.

THE GREAT AND LITTLE BEAR

THE GUARDS

Between the Pole Star and the Great Bear you will see two small stars, at no great distance from each other. These are the "Guards." As the stars circle round the Pole Star, you will

find that no matter what part of the sky the stars may be in, whether it be during the winter or the summer, the Guards will always be in a position between the Great Bear and the Pole Star. People of old thought that the Great Bear wanted to get at the Pole Star, so that he might add it to his stars. So, they said, the gods had put the Guards in between the Great Bear and his prey, to prevent him from reaching the Pole Star. The Guards, therefore, will always be found on duty, keeping the Pole Star safe.

CASSIOPEIA

If we learn the position of the Great Bear and also of the Pole Star, they will help us to find many of the other constellations. There is an old rhyme which says:

> "He who would scan the figured skies,
> Its brightest gems to tell,
> Must first direct his mind's eye north
> And learn the 'Bear' stars well."

Now, if you look at the sky on the opposite side of the Pole Star from the Great Bear, you will see a clearly marked capital W made up of five or six bright stars. This is called "Cassiopeia," or the "Lady's Chair." Cassiopeia, as

CASSIOPEIA IN HER CHAIR

you will see when you look for the W in the sky, lies on the course of the Milky Way. If you follow the Milky Way to one side, you come to Cepheus, which is not a very interesting group; but if you go to the other side, you come upon a bright group of stars called "Perseus," and beside Perseus, but outside of the Milky Way, lies Andromeda, or the Chained Lady. Andromeda is rather badly marked, but you may know it by a line of three pretty bright stars which lead to a great square formed by four bright stars. The great square, which you will easily recognize, is part of the constellation called "Pegasus," or the "Winged Horse."

All these names belong to the old Greek story which tells how Andromeda, the daughter of King Cepheus and Queen Cassiopeia, was chained to a rock on the shore, to be devoured by a sea monster, and was saved by the hero Perseus. Perseus showed the monster the snaky head of Medusa, the sight of which, you remember, turned even this dreadful dragon into stone. Cetus, the sea monster, has also been made into a constellation: but he has no very conspicuous stars.

CAPELLA

If you draw an imaginary line across the two stars forming the backbone of the Bear, starting from the end nearest the tail, and continue it onward for a good distance, you will come to a very bright star called "Capella," which you will know because near it are three little ones set in a triangle. If you have n't found it easily from the Great Bear's tail, start with the star that is at the bottom of the Dipper and nearest the handle. Draw in your mind's eye a line halfway between the two Pointers and keep on till you come to the first bright star. This is Capella.

Capella makes part of a beautiful five-sided figure, which some people call the "Charioteer." It is the second brightest star in the northern heavens. In the olden days they sometimes called this five-sided figure "the goat-carrier." Capella means "little goat." The shepherds used to watch these stars and call the three little ones near Capella "the kids." Sometimes they thought they could see a man carrying them in his left hand, while Capella went along beside. So the constellation was to them "the goat-carrier."

VEGA

Capella is the second brightest star in the northern heavens. Vega is the brightest. She is part of a constellation called the "Lyre," or "Harp"; but just now you should look at her

by herself. She is on the other side of the Pole Star from Capella. She shines with a steel-blue light. Vega is so far off that the light from it which reaches our eyes has been traveling since a time before many of you were born. It is one of those stars of the first size or magnitude which remind us that these stars at which we are gazing are really suns.

Vega is a very beautiful star, but the most interesting thing about it is that it marks the point of the sky towards which our own sun, with the earth and all the other worlds of our family, is traveling at a speed of more than one million miles every twenty-four hours.

THE STAR-CLOCK OF THE NORTH

Remember that the Great Bear and Cassiopeia never set in our northern sky. As they move about the Pole Star they have been called "the Great Star-clock of the North." "To watch these northern constellations as they follow each other in ceaseless procession round the Pole," a great astronomer has said, "is one of the most impressive spectacles in the sky. We are spectators of the movement of one of Nature's machines, the vastness of the scale of which, and the absolutely perfect smoothness and regularity of whose working, utterly dwarf the mightiest work accomplished by man."

STAR MAGNITUDES

We spoke of Vega as a star of the first size or magnitude. This is a phrase borrowed from the old days, when men did not realize that the stars might be at all sorts of different distances away from us, but thought that the star which shone brightest was of course the biggest star. We know that a small star comparatively near may look larger to us than a great one farther away. But the word "magnitude" was used when men really thought stars were large or small according to their appearance, and so it is used to this day. They called the biggest and brightest "first magnitude stars." Of these there are not many, only about twenty, in all the sky. The next brightest — about the brightness of the Pole Star and the stars in the Great Bear — are of the second magnitude, and so on, each magnitude containing stars less and less bright. When we come to stars of the sixth magnitude we have reached the limit of our sight, for seventh magnitude stars can be seen only with a telescope.

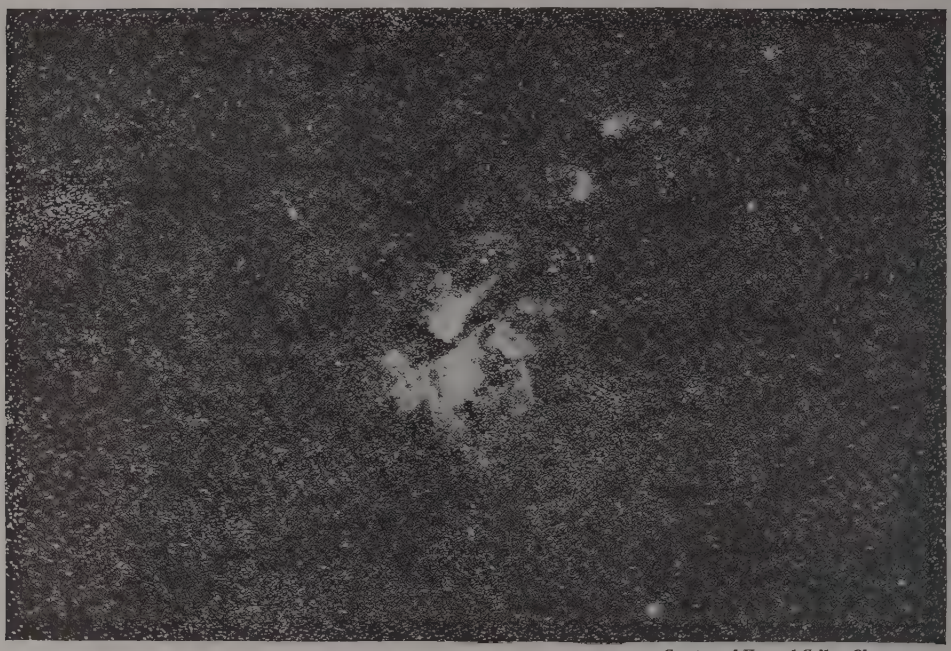
THE MILKY WAY — THE RAINBOW'S SISTER

In looking at Cassiopeia you cannot help noticing that there is a zone or broad band of very many stars, some exceedingly small, which apparently runs right across the sky like a ragged hoop, and Cassiopeia seems to be set in or on it. This band is called the "Milky Way," and crosses not only our northern sky, but the southern sky too, thus making a broad girdle round the whole universe. The ancient Mexicans called it the "sister of the rainbow." This delicate ribbon of light winds like a misty, gleaming veil in and out among the radiant stars and starlets, and when, on clear wintry evenings, the dark skies seem to extend without a limit and the heavenly lights stand out like diamonds on a velvety background, this mighty belt of light glitters in enhanced radiance, as if composed of millions and millions of the tiniest sparklets. It is the Milky Way.

SOME INGENIOUS SUGGESTIONS

The fable runs that Hercules, when a giant baby drinking at the breast of Alcmene, spilt a drop of milk, which ran down into the skies, spreading farther and farther, its trail forming the Milky Way. Theophrastus declared the gleaming ring to be the place where the two celestial spheres were joined together, and other wise men of ancient times believed it to be the route of the sun chariot, the Milky Way being the hollows which the wheels had worn in their journey lasting thousands of years. In one of these stories, Zeus, the great Greek god, grew tired of the foolishness of the people of the earth. So he called a conference of the gods to decide what should be done. According to the story, the gods on their way to the conference traveled over the Milky Way. Zeus was supposed to have destroyed at this time all except two of the people on the earth by flood.

They had an easy, offhand method of explaining the universe and its immeasurable glories in those distant times! To-day we know this



Courtesy of Harvard College Observatory

THE MILKY WAY

The Milky Way Galaxy is made up of millions of suns. They appear to be so close together that the ancients thought some one spilled milk in the sky. Our sun and its family is a part of the Milky Way Galaxy.

radiance to be due to the presence of millions of stars, millions of suns floating in space vast distances off. Democritus, indeed, a philosopher who lived five hundred years before the Christian era, shrewdly surmised that the Milky Way consisted of endless numbers of small stars; but it was left to Galileo and his telescope to justify this supposition by announcing its truth.

MILKY WAY A VAST GALAXY IN WHICH WE LIVE

The astronomers have made in recent years marvelous discoveries about the Milky Way. They have discovered that the Milky Way is a vast region stretching for millions of millions of miles in space. It seems to be so large that they speak of it as a universe or galaxy.

They have studied its shape and have found it to be shaped like a watch. But what is most interesting is that we are in the Milky Way. Our earth, in fact, our solar system, is completely surrounded by this Milky Way.

THE CENTER OF THE UNIVERSE

You will remember that the ancients thought the earth was the center of the universe. For thousands of years people thought everything revolved about our earth. But now we know that out of the millions of objects in the sky only the moon revolves about the earth.

Then, for a while, the astronomers thought our sun was the center of everything. But what a surprise it was when they found the sun was but a star!

THE SUN IS A STAR IN THE MILKY WAY

Now we know our sun is but an average star. There are some stars millions of times larger and much brighter than our sun, while some are smaller.

But did you ever think what a fine old sun

we have? If it was much larger or hotter than it is, it might make the earth hot, and there could be no life here.

Now we know that the sun is only a center of the solar system, and that the solar system is but a small part of the Milky Way. And the Milky Way is composed of millions of suns, some of which are much larger than our sun.

We may think Texas is a big state or our country is a big place, but what about our Milky Way!

MEASURING THE MILKY WAY WITH LIGHT

The astronomers have found the distance so big between the stars that they cannot use miles as a scale with which to measure it. Instead, they use light. They know light travels at 186,000 miles every second — that is farther than seven times around the earth. Light travels faster than anything we know of. Yet the Milky Way is so big, it would take light three hundred thousand years to cross from one side to the other. If you multiply it out to see how many miles it is across the Milky Way, you will need a big piece of paper or blackboard.

THE SUN PULLS US WITH IT IN ITS TRAVELS

Our solar system is not in the center of the Milky Way. In fact, the stars of the Milky Way, including our sun, seem to be moving. Our sun moves, dragging us and the other planets with it, at the terrific speed of twelve miles a second. The sun itself speeds many, many times faster than any of our racing automobiles and airplanes.

The sun makes one think of a person leading a dog on a chain. The dog walks about the person, first on one side and then on another. Still it travels with the person. The earth travels with the sun and goes around it at the same time. Still it goes along with the sun, traveling at the same great speed in space that the sun does.

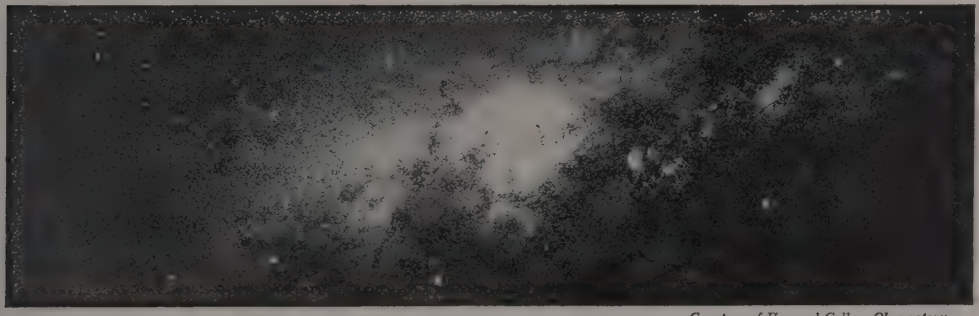
BEYOND THE MILKY WAY

What is outside our galaxy?

Astronomers find other great clusters and galaxies of stars outside our Milky Way. The stars in these are so far away that it takes light a million years or more to reach us. When you look at some of these stars, you see light which perhaps started on its journey before man appeared on the earth.

Many of these galaxies resemble our own Milky Way. Sometimes they are great giant clusters of stars. At other times the stars seem to be so close together that they look like a cloud of starry gas. Sometimes these are called "nebulae." Each of these big galaxies is like an island universe. Someone has compared them to swarms of bees. The galaxies are filled with stars just as a swarm is filled with bees. How much larger, however, a galaxy of stars is than a swarm of bees!

We now know the sky we look into is a big place. The universe of stars is so big that we have to stretch our imagination to understand it all.



Courtesy of Harvard College Observatory

A PART OF THE MILKY WAY

ORION, THE BULL, AND THE DOGS

We are always glad to come back in our imagination to our little earth, which is after all a good place to live.

ARE THERE OTHER WORLDS AND SOLAR SYSTEMS LIKE OURS?

This is something we cannot answer. Perhaps some of the stars or suns out in the sky have worlds revolving about them. Perhaps there are other solar systems. We do not know. Our telescopes are not big enough for us to see any planets that might be revolving about the other stars.

In fact, it would be difficult even to see our own sun, as big as it seems to us, from the other side of the Milky Way.

WINTER SKY PICTURES

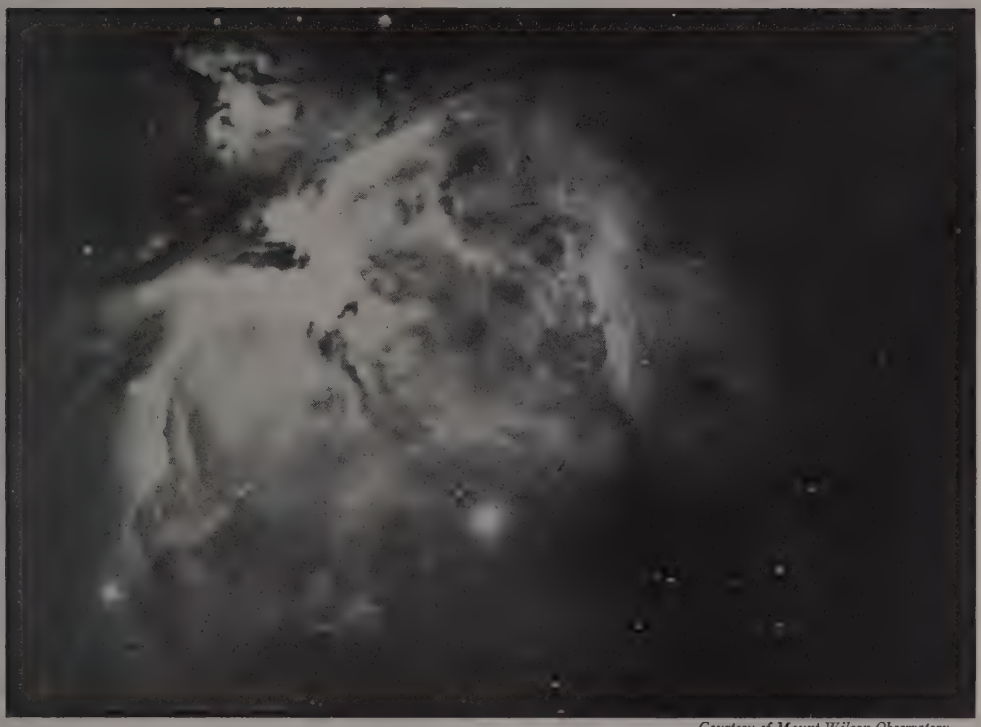
The figures of the northern star-clock are visible all the year round, but other constellations can be seen only in their seasons. In winter Capella gets high up into the sky, and then there is to be seen below her a little cluster called the "Pleiades." There is nothing else like this in the whole sky. It is formed of six stars, as it appears to persons of ordinary sight, and these stars are of about the fourth magnitude. Some eyes can see more than six. But though small, they are set so close together, and appear so brilliant, twinkling like diamonds, that they are one of the most noticeable objects in the heavens.

ORION

The most beautiful constellation in the whole winter sky is Orion, the Great Hunter. Right in front of you, as you look south on a midwinter evening — say in January — you will see him. Three bright stars, at equal distances from each other, make a slanting line across the sky. They are supposed to be the belt of a great giant, whose shoulders are marked by two stars higher in the sky. Two others, about the same distance below the belt, mark his knees, while a little group of three faint stars stands for his head, and a curved line of twinkling jewels below the belt makes his sword.

Over his left arm hangs a lion's skin which he holds out to shield him from the starry bull which is to attack him, — four faint stars in a curve giving its outline. In his right hand he holds a club with which to strike. Seven stars in a rather poor curve make the arm and the club. Do you see them in the picture on this page?

The Bull (*Taurus*, the Latin word for "Bull") is right opposite to him, and easy to find. See where Orion is going to strike. There is a triangle, or a big V. Five stars make it up, and the brightest of them, that very red star at the top of the left side of the V, is the Bull's red eye, glowering at the Hunter. Some people say the whole V is his face, and this is the brightest part of it; others think the tops of the V are the tops of the Bull's ears, and they do not count the stars beyond, which might be horns, great tall horns which reach up almost to Capella. Only the head of the Bull is shown in the heavens; but Orion has with him also his dogs. Look a little to the left, and lower down than Orion, and you will see the Big Dog.



Courtesy of Mount Wilson Observatory

ORION'S GREAT NEBULA

Sirius, the brightest star in the whole heavens, is to be seen in this constellation, and because it is the chief star in this group is often called the "Dog Star." Everyone ought to know Sirius. Near by, but higher up, is the Little Dog. They are both chasing along at Orion's heels, with the dog's fidelity.

The story is that the goddess of the moon had fallen in love with Orion, the mighty hunter. Her brother, the god of the sun, did not approve at all. He ordered the moon-goddess to give up Orion, but she would not. So he resolved to destroy Orion. One day, as Orion was bathing in a pool, the sun-god sent his brightest rays upon him, making him shine like a piece of bright gold. Then he called to his sister and said, "See that bright spot in the water. Let us see which of us can hit it." The moon-goddess, eager to show how well she could shoot, sent her arrows swiftly to the spot, and Orion sank, pierced to death. The moon-goddess was in great distress. She went to the sun-god and begged him to give back Orion's life. He could not grant this, but lifted him to the sky, where the moon-goddess, traveling by in her chariot, might look at him, and gave him his two brave dogs, which had always followed him on earth. Even in the heavens, Orion is a hunter and is trying to kill the Bull, who is attacking him.

PTOLEMY COPERNICUS TYCHO BRAHE KEPLER GALILEO

THE GREAT STAR-GAZERS

(Some of these men are also included in our story of "The March of Science," on page 259 of this volume.)

THE story of astronomy is the life story of men, men who all down the ages have spent their lives reading the wonderful open book of the heavens. The name of the first astronomer will never be known, — some Chinese star-gazer perhaps, some shepherd watching his flocks by night and studying the stars as he watched, or some Wise Man of the East who studied the movement of the stars in their courses. Old Chinese chronicles say the stars were studied in 3000 B. C. Astrology was famous among the Babylonians, Egyptians, and Greeks.

The first astronomer about whom we know is Thales, one of the Seven Wise Men of Greece, who was born in 640 B. C. and died in 556. He was the first to draw maps showing the position of the stars in the heavens. In 550 B. C. Pythagoras taught that the earth was not a disc surrounded by water, but a globe. He opposed the view of Thales that heaven was a huge crystal bell set over the earth, and the stars gilt-headed nails driven deep into it.

Aristotle, a Greek philosopher, was interested in astronomy, and ventured to suggest that the earth might be round. The next man to give his life to the study of astronomy was Hipparchus, a Greek scholar, who was born about 170 B. C. He made a catalogue of the stars, and was able by his study of the movements of sun and moon to predict quite accurately their times and seasons. Hipparchus was the greatest of all the ancient astronomers, "a most truth-loving and labor-loving man," as Ptolemy described him.

PTOLEMY AND COPERNICUS

The size of the earth was determined for the first time in the year 230 B. C. by Eratosthenes, a Greek astronomer and geographer, who also made a catalogue of 675 fixed stars.

Ptolemy, an Egyptian, lived two hundred years later. His theory of the earth as the solid center of the universe was held by the world for fourteen hundred years, until it was upset by Copernicus (1473–1543) and his successors. It is hard for us to realize what a serious matter it was for a scholar of the Middle Ages to advance a theory which was in opposition to accepted teaching. Ptolemy's idea had been adopted as reasonable and satisfactory. Man was the lord of the universe, living on the earth which was the center of all things. When Copernicus became convinced that the earth was not the center of the universe but simply a small member of the sun family, all moving round the sun instead of the sun, moon, and stars revolving round the earth, he knew that the publication of his theory would be received with ridicule and perhaps persecution. He therefore did not publish his book until shortly before his death. He might not have published it at all, but left it among his writings, if a young student of his had not prevailed upon him to have it printed. Copernicus was an old man when he made this decision, and was on his deathbed when the first printed copy was brought to him. To appreciate the genius of Copernicus we must remember that he lived in a time when the belief was universal that the earth stood still and the other worlds moved round it, that he spent, as he declares, thirty-six years after his great idea came to him in patient study toward its confirmation, and that he did his work before the invention of the

NEWTON HALLEY WM. HERSCHEL CAROLINE HERSCHEL LAPLACE

telescope. Little attention was paid to his discovery except among learned men, but he stands on the threshold of the new astronomy.

TYCHO BRAHE

Three years after the death of Copernicus, Tycho Brahe (1546–1601) was born in Denmark. While he was a student at the university the event happened which was to influence the course of his whole life. There was predicted an eclipse of the sun, and the boy Tycho, with his companions, watched for it on August 21, 1560. When it appeared at the right time, and he saw this strange shadow put out for the time the light of the sun, his enthusiasm was aroused. From that moment he gave all his spare time and money to the study of astronomy, purchasing instruments for star observation and sitting up half the night to watch the heavens. He could not quite believe with Copernicus that the earth moved round the sun, but he made a most careful study of the stars, collecting a wonderful array of accurate facts. His reverence for the wonders of the heavens was so great that he used to put on robes of state when he went to his observatory to study them with his instruments, which were the best any astronomer had ever made. He spent twenty-one years in observation of the heavens, discovering new stars, and new facts about old ones. To him we owe the foundation of that accurate observation which has made astronomy one of the most exact sciences.

THE FAMOUS STAR-STUDENTS OF THE MIDDLE AGES

Modern astronomy begins with the next group, of whom the leading figures were Galileo and Kepler. Tycho Brahe had collected facts. He left his records to John Kepler, a German, born in 1571, who set himself to study out from this array of facts a set of laws. Kepler accepted the belief of Copernicus, and tried to fit Brahe's careful observations into it; but he found, for instance, that on the plan of the planets moving in perfect circles, the time when Mars should be in a certain place was eight minutes different from the actual time. Brahe was too careful an observer to be eight minutes out of the way. So Kepler came finally to question that old, first theory of the ancients, which everyone since had held, that the planets all move in perfect circles. He tried the plan of an oval path, an ellipse, such as we have seen to be the path of the earth. By it all the times proved to be just right, and Kepler's *first law*, the law of ellipses, was proved.

He next tried to find out at what rate planets moved in different parts of their orbits, and was able to work out laws of the time which they took to travel their paths, as related to their distances from the sun, and also their actual distances from the sun. Kepler was poor, and the story of his struggles for money to keep up his studies is pathetic. But he finally proved his laws, and his delight was unbounded. In the book which gave his discovery to the world he said, "The die is cast, the book is written, to be read either now or by posterity, I care not which; it may well wait a century for a reader, as God has waited six thousand years for an observer." Kepler also published tables made from Brahe's observations, which are the foundation of our Nautical Almanac, paying himself, no one knows how, for the expensive type to set it up because he could get no one to advance the money. What Kepler did for astronomy it is hard for us to realize. Many

men could collect facts, but the man who had the wisdom and patience to spend his life pondering over them and working them into laws, which could be counted on for all time, did a service which made a new period of astronomy.

THE GREAT GALILEO

While Kepler was working in Germany, Galileo (1564–1642, born in Pisa) was carrying on his experiments in Italy. He first found out the principle of the pendulum by which many of our clocks are run, and of many other scientific truths. But his service to astronomy came through the fact that he was the first man to turn the telescope on the heavens. Up to this time all the study of stars had been with the naked eye, unaided by any instruments. With the use of the telescope Galileo opened a new world to astronomers, and found in it, as we have seen, many interesting and wonderful things, some of which he could interpret, some he could not. It shows the strength of the old views that in these years, while Galileo was making discoveries along the line of the Copernican theory, he was obliged by the university in which he was professor to teach to his students the old Ptolemaic system. The relation between these pioneer astronomers is interesting to follow out. Brahe left his charts and figures to Kepler, for him to continue the study which death compelled him to give up. Kepler sent Galileo one of his books, and Galileo wrote back: "I count myself happy, in the search after truth, to have so great an ally as yourself. . . . I should certainly venture to publish my speculations if there were more people like you." When Galileo did make his notions public, his prophecies of persecution were fulfilled. He was brought before the authorities in Italy, every copy of his book was seized and burned, and he was compelled to kneel before the opposing officials and declare that he would in future "detest the false opinion that the sun was the center of the universe and that the earth moved." Rising from his knees, tradition says, he whispered to one standing near him, "For all this, it does move." Even after this, he was imprisoned, then removed to his home, to live under guard in perpetual solitude. For the last four years of his life he was blind.

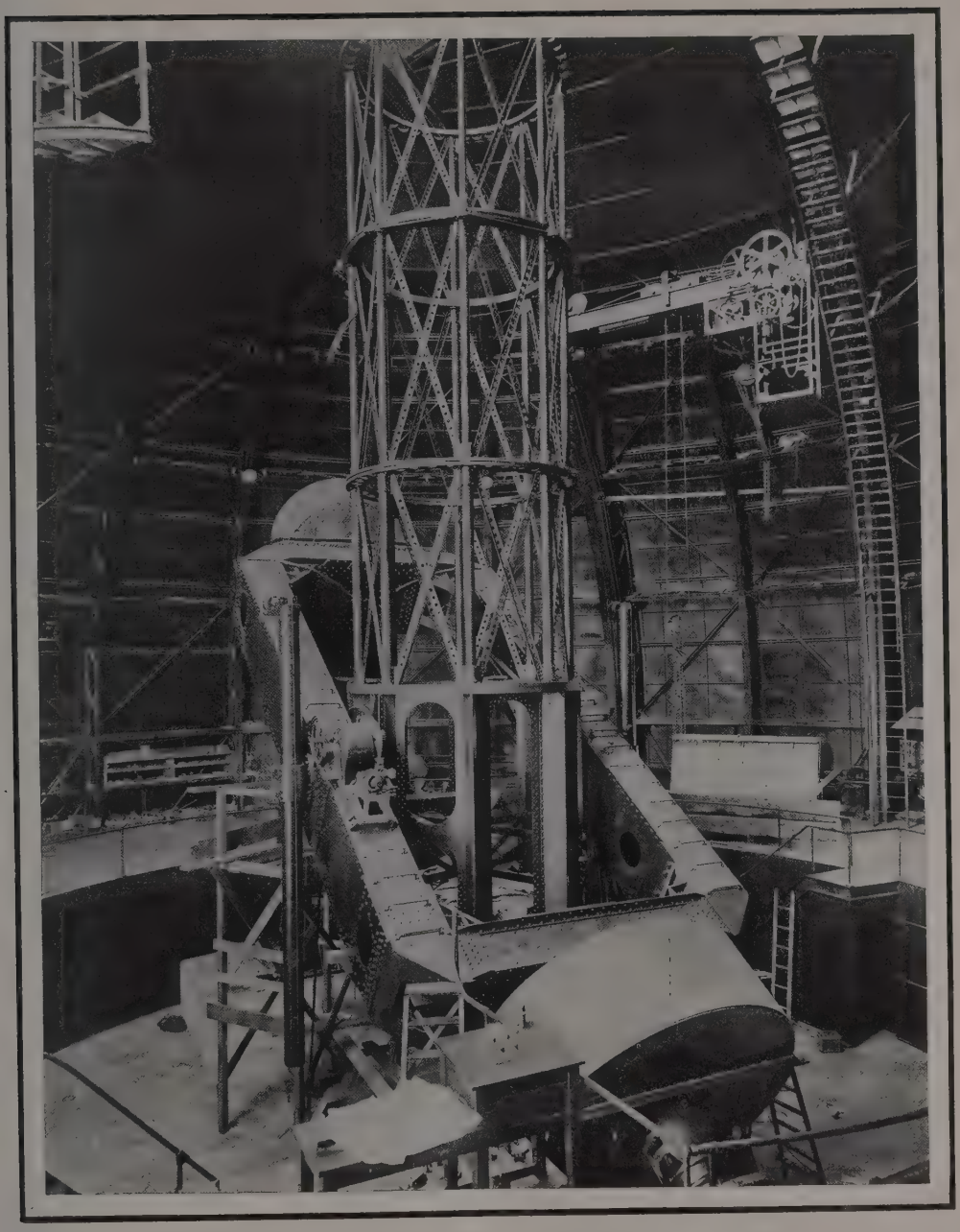
NEWTON, KEPLER, AND HALLEY

Galileo had given the world the law of bodies falling to the earth. It was Sir Isaac Newton (1642–1727), an Englishman, who applied this theory to the world of planets and gave the answer to the question, "What binds the sun system together?" Kepler had found out the laws of the motions of the planets. Gravitation, as Newton worked it out, was the greatest discovery ever made in the history of astronomy. By extending the theory of gravitation to the movement of the moon round the earth, Newton showed that the laws which Kepler had discovered were the laws of universal gravitation. To him we owe the great law, known as the Newtonian law, that "every particle of matter in the universe attracts every other particle." The far-reaching effects of this law were not fully grasped even in Newton's day. Newton also made important discoveries in the nature of light. He was not a rich man, and would not have been able to pay for the publication of the book containing this discovery, had not his friend, Edmund Halley, the discoverer of the comet of his name, had the book published at his own expense. Newton received more worldly honors than those who had preceded him. The value of his discoveries was recognized in his lifetime, and he was given titles and presents.

Halley was the next noted English astronomer and found out many facts about Venus as well as about comets. James Bradley and James Ferguson, both friends of his, were also of service to the cause of astronomy.

BRADLEY AND FERGUSON

Bradley helped to change the calendar of England from the old calendar to the one we use. He attacked the problem of the distance of the stars, and in this work discovered "aberration of light." This depends on the motion of the earth. We can get the idea while walking in the rain, when the drops are coming straight down. The faster we walk, the more we have to tip our umbrella forward for protection. Thus, when the earth is moving so fast athwart the direction in which the light is streaming from the stars, the stars appear displaced forward. Ferguson was a Scotchman. His name



THE 100-INCH REFLECTOR AT THE MOUNT WILSON OBSERVATORY, CALIFORNIA

should be remembered for three things: he made important observations, he constructed extraordinary instruments and machines, and he gave lectures and did much to make astronomy popular. It was, besides, his book on astronomy which started William Herschel on his career as an observer of the heavens.

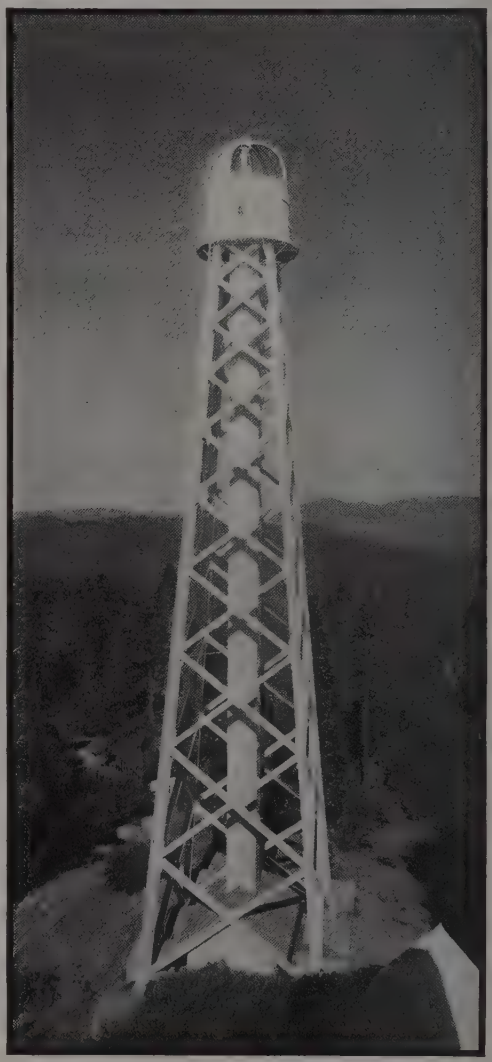
WILLIAM HERSCHEL

Astronomers before Herschel had occupied themselves only with the solar system, the little group of planets moving round the sun. The stars were observed, but mostly as convenient reference points for the observation of the moon and the planets. It was left for Herschel to begin the conquest of the stars, to start astronomy on a new path. On his tombstone it is written: "He broke the barriers of the skies"; and it is true. He stands second to Newton among the pioneers.

William Herschel was born at Hanover in 1738, and was trained as a musician to play in the band of which his father was leader. After a time he went to England, and there set up a home with his sister Caroline. He began to take a deep interest in astronomy, and as he was too poor to buy a good telescope made one himself. But for his sister he could never have become an astronomer. She helped and encouraged him in all his work. Sometimes he had to hold his hands on parts of the telescope for sixteen hours, and she would give him his meals and read to him to break the monotony of the long hours.

With this telescope Herschel discovered the planet Uranus, and from this moment was a recognized and honored astronomer. Together the brother and sister worked, discovering, it is said, about seventy million stars with his mighty telescope, besides many star clusters. When you learn that as you look up at the heavens where there seem to be a great many stars, you do not see more than two thousand, you begin to get a little idea of what a new world Herschel opened. He was king's astronomer, and his discoveries made such a stir in the world that sometimes he would have to be for days together "the showman of the heavens," pointing out to others the wonderful sights he had seen.

Since Herschel's day many great men have devoted their lives to the study of the heavens, but those whom we have named are the pioneers of astronomy, the men who made the first steps in the conquest of the unknown. With instruments which would to-day be considered quite inadequate, they began to map the heavens.



TOWER TELESCOPE AT MOUNT WILSON

This 150-foot tower is used for solar work. In the laboratory at the base of the tower an image of the sun about 16 inches in diameter is formed. Below this is a well 80 feet deep in which is set the spectroscope which completes the equipment.

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THE GRAND CANYON OF THE COLORADO

An excellent place to learn the story of the earth.

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THE EARTH A STORYBOOK

THE EARTH'S STORY OF ITS BIRTH

THE earth is her own story teller. She has kept a diary, a book written by herself, which has mountains and rivers, valleys and volcanoes, caves and ocean shores for its pages. Some of the records were put down thousands of years ago, and are rather hard to read; others are only a few hundred years old; still others are being written to-day, and we are watching them in the making.

Before men had read the book of the heavens aright, they could not tell the true story of the earth. Only when they had studied the sun, moon, planets, and stars, and had found out that the earth was only one small planet in the solar system, could they begin to understand how this little planet of ours came into being.

HOW THE SOLAR SYSTEM BEGAN

Man has always tried to solve the puzzle of how our earth was made. There are many signs, which, if carefully studied, will help us solve this riddle. Of course, no one knows exactly, because all this took place millions of years ago. Pierre Simon Laplace (1749–1827) offered the "Nebular Hypothesis" as a story of how our earth began.

According to this theory, all the material of our solar system was once a mass of glowing hot vapor. It was somewhat circular in shape and

turning around very rapidly. As it cooled it became smaller and smaller, and turned faster and faster. It looked like a big fireworks pinwheel that shot out great rings of gas. These rings became the planets, and the material that was left became our sun.

Each ring, after being thrown off, came together as a rotating ball. Each ball cooled, became smaller, turned faster, and other rings were broken off from it. These pieces became moons of the planets. In this simple manner our solar system was supposed to have been formed.

For some time Laplace's theory was thought to be a very good one. To-day, however, the scientists do not accept this explanation.

Two American scientists, Chamberlain and Moulton, have explained the formation of the earth in a different way. They have made a hypothesis, or story from the facts, which they had gained by studying both the stars and also the rocks of the earth. This is their story.

A long, long time ago there were no planets about the sun. It was just a star without a family. But in its travels it came near another star. The visiting star got so close that it pulled out some of the gassy material which is always spouting out of the sun. This material was pulled out so far that it never dropped back into the sun. The passing star and the sun both pulled on the material and started it spinning about the sun.

This material collected to form the planets. At first, the planets were much smaller than they are to-day. They grew larger because of the falling of meteors and other material, called planetesimals, pulled off the sun.

LAPLACE'S IDEA OF THE ORIGIN OF THE SOLAR SYSTEM

Study this picture and observe the shape like a spin wheel, with the "sun" at the hub and the planets left behind on the rim of the wheel. Out of a gassy vortex such as this our earth and the entire solar system may have emerged so long ago that we cannot conceive it. Systems in much the same condition can still be seen in the sky, whirling through space with a velocity with which nothing in this world can compare.

Courtesy of Popular Science Monthly

THE BIRTH OF THE EARTH

This picture shows a modern idea of how the earth was formed. Ages ago, by this tidal theory, another star came so near the sun that enormous waves of gassy material were pulled out. Part of this fiery gas went so far that it never dropped back, but formed our earth.

HOW OUR ATMOSPHERE, OCEANS, AND MOUNTAINS WERE FORMED

When the earth began its story as a body separate from the sun, it was very small. No one knows how large it was, but it might very likely have been about one-tenth of its present size. Whether or not it had an atmosphere would depend upon its size.

Our moon does not have an atmosphere because it is not large enough to hold one. Since our earth was very small it probably had a thin atmosphere, somewhat like that of Mars. This atmosphere was added to by planetesimals made of gas. Meteors, or shooting stars, falling into the earth gave off gas. These gases and the gases from volcanic action, later, built up gradually our present atmosphere.

IF THE EARTH WAS SOLID, HOW DID VOLCANOES DEVELOP?

As the earth grew in size, it created great weight and pressure upon its interior. This pressure caused heat for the same reason that a nail will get hot if you pound it with a hammer. Substances having radioactivity, such as radium, also acted to make the inside of the earth hot. Since the earth loses heat very slowly, the temperature gradually rose higher and higher. Some parts melted and changed to liquids more easily than other parts. As a result of this action, some spots of the interior were liquid while the rest was solid. The liquid material gradually worked its way towards the surface. If it struck a weak spot at the surface it burst forth as a volcanic eruption. At one time the earth had many volcanoes. The geologists call this period the "Volcanic Age." Of course, that was a long time before man lived on the earth.

HOW WERE THE OCEANS FORMED?

As the temperature of the air became less, some of the water vapor of the atmosphere condensed to a liquid. This liquid fell upon the earth as rain. What happened to the water which fell as rain? Some of it evaporated, some sank into the ground, and the rest ran into hollows and formed pools. The hollows thus became the beds of oceans.

The earth's surface was not smooth. Some parts were built up more than others by the irregular addition of planetesimals. These land and water areas gradually became larger by their own action. The air moved about, causing winds. The wind and the water ground up the rock and made soil. Now plants could grow, since they had the three things they needed, water, air, and soil.

Our ideas of how the earth was formed have changed many times. There is a great difference between the myths of the early Japanese, Indian, and Norse peoples about the creation of the world and the hypothesis, or explanation, of the scientists. We can be sure the scientist is more nearly right because he looks at the stars and studies the rocks. Still it is quite possible that some scientist will learn new facts which will sometime make a better story than any that have been written up to the present time.

THE EARTH OUR DWELLING PLACE

First of all, the earth is our house, where we live. Geography teaches us a good deal about this house. We know its shape and size; how much of it is dry land and how much is covered by water; its valleys and mountains, plains and oceans; where its continents are, and what they are like. Think of the house in which we live. We know its general shape, and whether it is a large or small house; we know how many rooms there are, about how large each room is, and what it is used for. But is that all we know about it? If we are curious, we want to know what the house is made of, how much of it is stone, brick, iron, wood, plaster, or other things; how it was built, where its materials came from, and how they were made into a house. We are so used to our houses that perhaps we do not think of some of these things, but a cave dweller, who had never seen a house "built with hands," would ask all these and a dozen more questions if he saw our house.

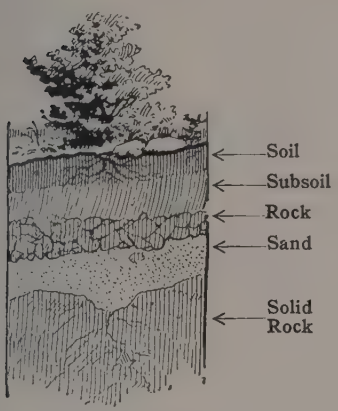
Just so we are used to the earth-house; but when we stop to think, there are all these questions to be asked about it. What is it made of? Is it all of the same stuff? Was it built all at once, or has it been added to or changed, as a house is sometimes made over or given a new bay window? Where did its materials come from? And how were they brought and placed where we find them?

Then we like to know who lived in the house before us. Sometimes a long line of families has lived in it. Perhaps they all died, or some moved and new people came in who had been living in another place. Sometimes they left signs behind them. If we find toys in a room, we know that a family with children has lived in the house.

Every one of these things has happened in our earth-house. Animals and plants that lived on the earth in earlier days have left behind them parts of the framework of their bodies; cliff dwellers have left their cooking dishes, warriors their weapons, so that we can find out much about their kinds and ways. And the earth itself has written the story of its own changes on its surface for us to read.

WHAT IS THE EARTH MADE OF?

If you have looked about you, you know that the ground is different in different places. Here we find clean fine *sand* that we can sift



ROCK STRATA BELOW EARTH'S SURFACE

through our fingers without soiling them. It is clean even when it is damp. We pat it together into a shape, but it falls apart again. In the country it is yellow, and on the seashore it is nearly white and very fine. There the ground is a great bed of *clay*. If it is dry it feels hard, but it will crumble; and if it is wet it is soft and sticky. We can soften it and make it into whatever shape we like, and when dry it will hold the form we have given it. Both sand and clay, when ground fine, make dust that the wind blows about. In another place there is neither sand nor clay, but rich *soil*, in which plants grow thickly. Where there is good soil people do not let wild things grow, but plant what will be of use to them.

SAND, CLAY, AND SOIL

Mixtures of these three — sand, clay, and soil — make the most of the ground under our feet. People sometimes call it *dirt*, a word which means something else. Its real name is "earth," because it is the material of which the surface of the earth is made. Some places show layers of each kind, with the upper layer of soil, the one next below sand, and the lowest clay — or clay, then soil, then sand.

Sand and clay may be very deep. Good-sized hills may be gravel, which is a coarser sand, or they may be clear clay; but underneath there will be found solid rock. *Rock* or *stone* is the true earth material; the clay and sand and gravel are also made from rock, as we shall see.

So the first chapter in earth's storybook is the story of rock. This chapter is called "Geology," from *Ge*, the Greek word for "earth," and *logos*, "the science of," — the science or study of earth, whose crust is made up of rock.

THE SEA A SOIL MAKER, OR HOW SOIL IS MADE FROM STONE

Go down to the seashore and stand on a cliff during a storm, and you will see how rocks are being made over into gravel or sand. Each huge wave, as it comes tossing and foaming up the beach, lifts up the stones lying there and dashes them against the foot of the cliff. As the green, seething water rushes back again, you can hear the harsh roar of the stones as they grate and grind each other while they are dragged down the beach, only to be caught up and swept once more towards the foot of the cliff. By this rubbing and grinding against each other their sharp corners are being worn

Courtesy of U. S. Geological Survey

SEDIMENTARY STRATA

Showing how earth material has been deposited in layers.

off. Then the round, smooth stones are worn away until they become little pebbles, and finally the particles which make up the soil.

The storms on the seashore do this work on a

Courtesy of U. S. Geological Survey

FAULT NEAR YELLOW CREEK, COLORADO

Showing how the level layers have been disturbed by some force of Nature, probably an earthquake.

big scale. Every brook and stream does it in a little way. Wherever water is working on stones, it is wearing them down and rubbing them against each other, making them over into the tiny pieces of matter which make our soil.

HOW GRAVEL, SAND, AND MUD BECOME ROCKS

But if water helps stones to grind each other into soil, it also helps to move sand, gravel, and mud and put them in places where they become rock. If you are in the country, go out after a heavy rain and watch the water running down the road, carrying with it sand, gravel, bits of paper, sticks, and whatever lies in its way. All this matter is carried along with it, so long as the water can flow swiftly. But here is a hollow, which the water must fill. Now it must run more slowly, and it drops the heavier part of its burden. This matter sinks to the bottom of the pool. If the rain lasts long enough, the hollow may be all filled with matter which the water has dropped.

This may seem a very unimportant happening in a tiny pool by the roadside; but it is a small sign of what is taking place all over the world. Wherever there is standing or slow-moving water, the heavier matter in it will sink to the bottom of the course over which the water is flowing. Take a glass of water and leave it standing for a day. Something which we call "sediment" (that which has settled) will sink to the bottom of the glass. When great heaps of soil are dropped by the water and left to harden, they gradually form into rock. Rocks formed in this way have been given two names, — water rocks, because water helped to make them, or *sedimentary* rocks, because they are really hardened sediment.

WHAT THESE ROCKS HAVE TO TELL

There are three great classes or kinds of rocks, and every one has a story to tell. The easiest story to read is that of sedimentary rocks. Their name tells how they were made. Now try putting two or three kinds of material into a glass of water. As they settle to the bottom, you will see that the coarser, heavier particles, the pebbles perhaps, reach the bottom first, and make a heavy layer; then the next lighter settle on top of that, and the still lighter above that, till the water has really sorted all the stuff you dropped in according to its weight, and laid it in layers. This happens if you drop all the stuff in at once. But drop in some sand first, and let it settle; then put in pebbles. Now the water cannot lift the sand and put the pebbles below, even though they are heavier. The pebbles will rest on the sand. If someone came in and looked at that glass of water, he

could tell that you dropped the sand in first, and then after it had settled put in the pebbles. The glass of water would tell its own story.

Just so mountains and cliffs and canyons, cut in the rock by watercourses, tell their story to us. They are built in layers. Anyone can see that by looking at them. Sometimes the layers are tilted out of the level, as you see, probably by some underground disturbance, like an earthquake; but they are plainly in layers, with lines to show how they run. The layers may be of different kinds of rock, — hardened clay, sandstone, and limestone, all carefully laid one upon the other. Some may be as thin as a piece of paper; some very deep. But they show by these even layers that they were left there by water; and by their age and weight we can tell something of the story of how and when they came there. A queer story it is.

THE STORY OF THE LAYERS

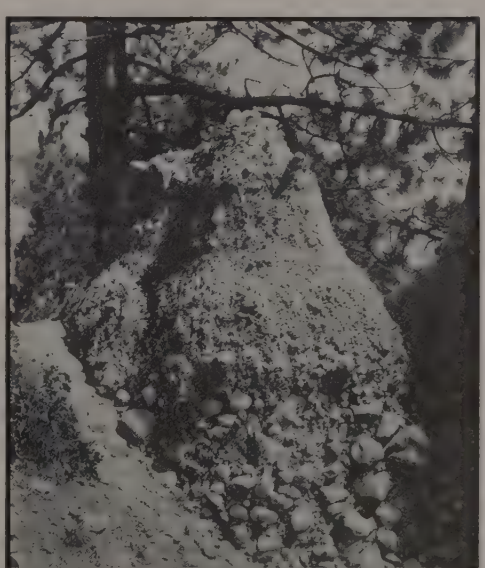
Each layer is a chapter by itself. If we begin with the lowest layer, we shall get the first chapter, which will be millions of years old. Often it will have signs which will give its place in history.

Suppose at the height of a mountain top we find layers of rock which are plainly made of sand and marine shells, ground up and hardened, but still holding enough of their original form to show they are shells. Sea shells are never found where there is no ocean. So there must have been ocean at this place sometime, which dropped this layer of shells before it shrank away to its present shores. But here, higher than that, is a layer of peat, a marshy vegetable substance, only slightly hardened by the pressure above it. This would show a time when there was a lake and it was gradually choked up into a swamp. High above this, however, is a layer of smooth, well-worn pebbles fitted by a sort of clay into each other and making a whole crosswise slice of the mountain. Water, again we say, for nothing but water or ice could round off the corners of stones to that smoothness. They are like the pebbles at the bottom of a brook. You see, we have quite a story already. Twice, at least, this high mountain of ours has been under water long enough to have a whole layer of rock stuff slowly dropped down. Then it has been a marsh, and between times it has been out of water long enough for each of these layers to harden.

Let us leave our mountain top and go to the bottom of the sea. Here are rocks which we expect to find only above water. They must have been hardened by great heat. Were the ocean beds once empty, and the mountains covered with water?

WHAT ARE FOSSILS?

Layers of rock tell us much by the material of which they were made; but the strange beings imprisoned in them tell even more. In these layers we find what we call "fossils," pieces of rock which look like animals or plants frozen into rock. They are different from the rock in which they are buried. How did they come to be there? Geologists explain them this way: These fossils are the remains of plants or animals which were buried in the earth. They died and dropped into a soft bed of mud or clay, probably on the shores of great bodies of



Courtesy of U. S. Geological Survey

A PUDDING STONE

Small stones, probably formed by the action of water on rock, are the "plums" in a mixture of hardened mud.

Courtesy of Field Museum of Natural History

BEFORE LIFE EXISTED ON THE EARTH

Our beautiful world of to-day was once a barren stretch of rock and water.

water. The water was drained off, the mud hardened, but the harder parts of the animal or plant kept their shape and hardened too. If they had been open to light and air, they would have fallen apart and lost all their first shape. But they lay shut away in their beds of mud and did not change except to harden. These fossils are sometimes of plants and animals much like those on earth now, but more often are unlike any which we have ever seen. So they help to tell the story of the earth before we knew anything about it.

FIRE ROCKS AND OTHER KINDS

Before we give the story of the earth as men have read it in layers of rock, we must tell about the other classes of rock besides the sedimentary. These are first the *igneous*, or fire rocks, which have been in a melting state and have grown solid in cooling. The story of how our planet was made shows how many of these there must be. They are named for the Latin word, *ignis*, "fire." Granite is a fire rock; sandstone is a sedimentary rock, made of bits of sand; and chalk belongs to a subdivision of sedimentary rock called *organic* rock, made of the remains of plants and animals, shells and bits of hardened decay of mineral or vegetable matter, ground up and mixed firmly together.

Take a piece of each kind of rock, if you can get hold of it, and look at it carefully through a magnifying glass or a microscope. The granite will look as if it were formed of crystals, thrown and pressed together by some great force, which we know to be heat.

Look next at the sandstone. It appears to be formed of small grains, each one rounded and worn as if rolled in the water. It is made of sand arranged in layers and lines and cemented together. Under the magnifying glass the grains of sand can be plainly seen. By rubbing, the sand can be rubbed out of the stone.

Hold the piece of chalk over a tumbler of water, and brush or rub it till the dust falls and makes the water white and muddy. Let this settle; and then, after pouring the water off, spread some of the soft sediment in the tumbler on a piece of glass and examine it under the microscope. The white powder appears to be composed in part of minute shells and bits of broken shells.

The third class are the *metamorphic* rocks, such as slate, gneiss, and schist. These are rocks that have been changed, or metamorphosed, by great pressure or heat, or both. Thus limestone is changed to marble, sandstone to quartzite.

AGES OF EARTH BUILDING

Mother Earth built her house in layers. That is plain. She used water and heat and sunshine to help her place and harden it. When we find the same layers in many parts of the earth, and the same fossils in certain layers, we can imagine the order in which she did it, and the tools she used at different times. These periods, or geo-

logical eras, we call "earth ages." We shall tell of them here as they have to do with earth building, leaving the fuller story of the life in each age for the fascinating story of "Animals Before Man" (pages 274–288).

THE ARCHEOZOIC, OR "BEGINNING LIFE," AGE

The rocks laid down during this era are the oldest. So deeply buried are the lowest of these rocks that they have never been found. The bottoms of the deepest canyons, like the Grand Canyon, are higher than the lowest layer of these rocks. This means that they were laid down millions and millions of years ago. No river has ever worn down to the bottom of the rocks of this age.

These beginning rocks contain very few fossils, for there was little or no life on the earth at this time. The earth would not then have been a pleasant dwelling place. Can you imagine what it was like? It was a time when the earth was collecting an atmosphere. The ocean basins were starting, too. Probably both the atmosphere and the oceans were smaller than they are to-day. If you had been there, you would have found it rather dull. There were no trees, no grasses, no animals large enough to be seen without a microscope.

Life was, however, probably starting at this time. This era is therefore called the Archeozoic, which means "beginning" or "first life." Little plant cells must have started first. They were so tiny that thousands could have found space in one drop of water. Later, tiny one-

Courtesy of Field Museum of Natural History

THE EARTH AS IT MAY HAVE LOOKED TO THE FIRST LIVING CREATURE

celled animals started. They lived by eating the plants. To-day animals depend on plants for food. So we may be sure that plants started first.

No one knows how long this "beginning" age lasted. We may be sure it was for many millions of years.

THE PALEOZOIC AGE

Then comes a very long age with a very long name, which has a very simple meaning. This is the Paleozoic (pay-lee-o-zöic) Age, from *palaios*, meaning "very old," and *zoë*, "life." In the earth layers of the Archeozoic Age there were very few fossils. The Paleozoic is the first which is well supplied with fossils. This age was very long — no one knows how long. Its sediments or layers are twenty-five thousand feet thick in some parts of the world. Mother Earth took a long time building this part of her house. Many of the layers are tilted and tipped, like the waves of the sea, showing great disturbances very deep underground. Most of Europe and North America seems to have been above sea level. The greater part of the Mississippi Valley seems, so the geologists say, to have been a shallow inland sea, which was to become in the latter part of this long age an immense marsh.

The fossils in the lower layers show life only in its simplest forms, sponges, and plant life. In the higher layers come insects, then fishes, and finally trees and forests, the later decay of which makes our great underground coal-fields. In the long periods of earth building, great forests had grown up and decayed. In some places the vegetation had grown from 100 to 8,000 feet, and had then been covered up. Time after time, in these millions of years, great glaciers had swept down from the north. When they retreated, they left great coverings of dirt and rock over this earlier vegetation. On the top of this dirt other vegetation grew, decayed, and was covered up. Thus we have a great sandwich formed of rock and vegetable matter. The rock and soil form the "bread layers" and the vegetation the "filling in between."

Great forces then set to work and crushed, folded, and squeezed this sandwich. The vegetation was changed by this pressing and hardening process from peat to soft coal, and then to hard coal. Thus the sunshine of a million years has been stored in the earth, and man is now using this energy for heat and power. When we burn coal to-day, we do so because the energy of the sun was stored away in plants during the Paleozoic Age, millions of years ago.[1]

No geologist knows how long this age lasted. Some think it may have been for as long as 360 million years.

THE MESOZOIC AGE

During this age, as during the earlier ages, the earth did not look much as it does to-day. This was the time when the reptiles flourished, the dinosaurs and other interesting animals of which you will read in "Animals Before Man." During this period the first known bird appeared.

There were great forests during this time, some of which turned to stone, or, as the geologist says, "petrified." Among them are the petrified forests of Arizona. There was great development of mosses, lichens, ferns, and evergreen trees. Flowers were probably developed, but did not have any great importance in this age. The Mesozoic Age probably lasted one hundred and thirty-five million years.

THE CENOZOIC AGE

This is reckoned the third great geologic era, the Paleozoic being counted as the first, the Mesozoic as the second. During this age the life on the earth was beginning to look more as it does to-day.

Up to this time there had probably been very few flowers. Now flower-bearing plants appeared. At one time maples, camphor trees, fig trees, laurels, and other trees grew in great forests in Greenland. To-day Greenland is covered with a very thick ice sheet. By this fact we know that at some periods of earth history the Arctic regions have been much warmer than they are to-day. Insects developed, and many new mammals appeared. The ancestors of tigers, horses, rats, wolves, dogs, and monkeys were running over the earth.

[1] See also Volume Ten, page 59.

Courtesy of Popular Science Monthly

AS LIFE MAY HAVE APPEARED ON THE EARTH

OUR COAL FIELDS AS THEY MAY HAVE LOOKED LONG AGO

All this vegetable and animal life perished to make the coal that is a world's fuel.

THE FOURTH AGE (QUATERNARY)

We are living in the Fourth Age. It has not been completed. This story we cannot finish. It will take millions and millions of years before the Fifth Age will start.

When the Quaternary Age started, the earth was beginning to look much as it does to-day. It was no longer a barren rocky place, as it was in the First Age. It was now covered with soil and carpeted with grass and beautifully colored flowers. Insects were flitting about from flower to flower. The earth was no longer silent, for there was the bark of the wolf and the dog, the croak of the frog, and the singing of the birds.

The Quaternary Age is divided into two parts, the Ice Period and the Present Period.

During the Ice Age, it grew cold. More snow fell in the winter than melted in the summer. After thousands of years, so much snow had fallen and turned into ice in northern North America and Europe, that it pushed southward. As it went it carried rocks and soil with it. As these rocks were dragged over other rocks, great scratches were formed.

The ice came down as far as the present Ohio and Mississippi rivers. Then, after thousands of years the earth grew warmer, and the ice melted. As it melted, it left behind much rock and soil. Sometimes this material dammed up rivers. Many lakes were formed in this way, among them the Great Lakes. If you look on the map, you will see that there are many lakes in places where the ice had been.

The rivers were changed out of their old courses by the ice. After the ice was gone, they sometimes made new beds and went tumbling about making waterfalls. Niagara Falls was made at the close of the Ice Age.

There have been many ice ages. The earth has been visited by many such cold spells. The last one is most interesting, because we can see so many signs of it. It is known as the Pleistocene Ice Age.

We are living in the Present Age. You can tell for yourself this part of the earth's story, about man and his great brain, and his inventions. Man is the first creature on the earth which has been able to study the story of the earth. The ant, the elephant, the beaver, and dog are wonderful animals. But they never used a telescope to look at the stars, or studied the rocks to learn the earth's story.

We have now come to historic times. Man is writing the story in books. Before the Present times, we had to depend on the rocks for our story.

The Third and Fourth Age, up to the present, together cover a period of some fifty-five millions of years. Most of the story of these two ages is in the rocks, for man has been writing in books for only a few thousand years.

CHANGES IN THE EARTH'S CRUST

There were great changes going on on the earth during all of the earth's ages. Sometimes the land surface, or continents, grew larger, and land appeared out of the oceans. At other times, the land sank and the ocean water came in over the land. There were times when some of the continents were connected. At such times the plant and animal life passed from one land to another.

At some time the Arctic and Antarctic regions have been warm. This is shown by fossils of tropic plants found in Greenland and Spitzbergen, and the coal deposits on the Antarctic continent.

Great mountain systems were formed and then worn down to valleys. At other places, sea bottoms were lifted up and became tops of mountains. To-day, sea shells are found buried in rock at mountain tops.

All of this shows the earth is very old — millions and millions of years old. Some think

A MONUMENT CARVED BY WATER

An example of what geologists call "weathering."

it may have been two billion years since the earth material was pulled out of the sun by the passing star.

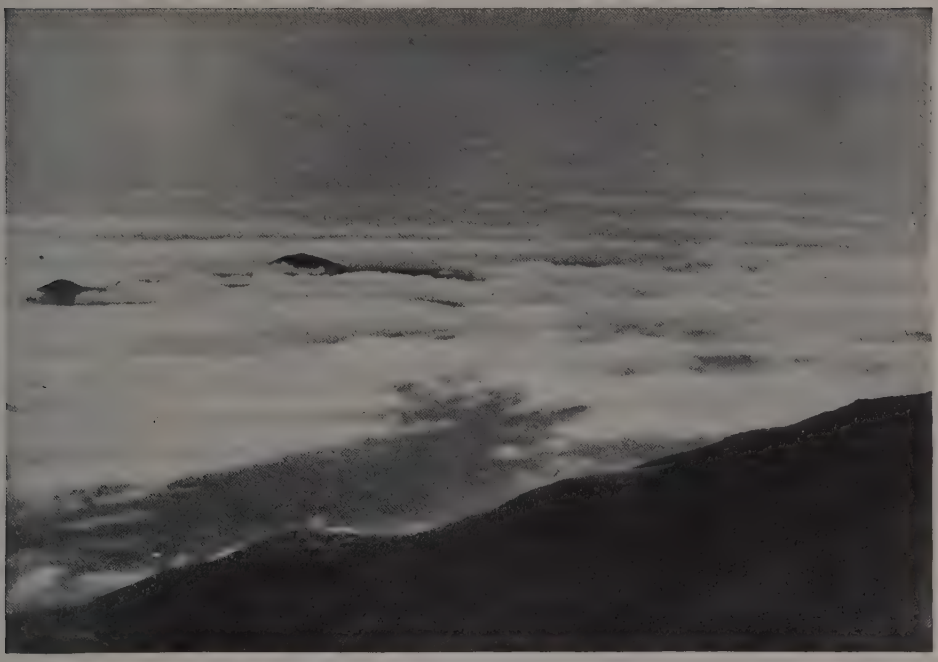
We shall find out later something about the forces which have brought all of these changes on the earth. Those of which we have spoken happened in prehistoric times; but there are changes which we can see going on now. One of them is what is called "weathering." Whenever any surface, even of what we call solid rock, is exposed to the action of the weather, it is gradually worn away. Heat and cold expand it and contract it, though ever so little; water freezes in its openings and splits them farther apart. Even the air has chemical elements, or acids, which unite with elements in the rocks to change them and wear them away, just as damp air rusts iron, or sulphuric acid eats holes in cloth. Weathering works slowly, but it makes changes. Then there is the work done by water in its various forms, — rivers in their valleys, ocean on its shores, still water and running water. But the most violent changes are those made on the earth's crust from within by earthquakes and volcanoes.

Many of these more violent or spectacular changes are described in "The Earth a Wonderbook," which follows in this volume.

EARTH'S THREE BLANKETS

As our planet has cooled down from a cloud of fire-mist, it has wrapped itself in three coverings, each of them equally necessary to man. The first is the rock blanket of the earth's crust, on the surface of which we live. We can use only about one-fourth of this crust for our dwelling place, because three-fourths of it is wrapped in a water blanket. We can travel across this water blanket in great ships, but we cannot make our homes on it. Still we could not live without this water blanket, for water is needed for every form of life. We could not live on the rock crust or travel on the water, however, if it were not for the great unseen air blanket which surrounds them both, covering the whole globe.

This air blanket is two hundred miles high, and perhaps more. It is so thick and so much more like water in its behavior than like rock and soil, that we often speak of it as the ocean of air in which we live, picturing ourselves as walking round on the bottom of this ocean as crabs crawl about at the bottom of our water ocean.



ABOVE THE CLOUDS IN THE WHITE MOUNTAINS OF NEW HAMPSHIRE

Showing the foam-like cloud blanket of the earth.

THE OCEAN OF AIR IN WHICH WE LIVE

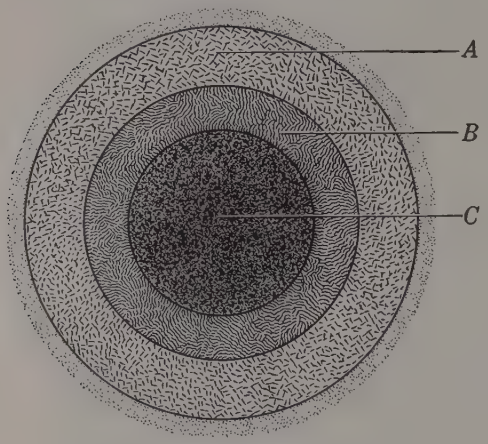
One of the reasons why people found it hard to believe that the earth was round and was dashing through space at the rate of nineteen miles a second was the stillness of this air ocean. If we were whirling round at this rate, surely there would be a great draught. The air would blow so hard that it would pick us up and toss us off into space. The air certainly would, if it rushed past us. But, as a matter of fact, the air goes with us. If you are inside a railway car with the windows closed, you do not feel the rush of air, because the air in the car travels with you; and it is the same thing on the earth. The air which surrounds the earth clings to it and goes round with it. The force which holds it down is the force of gravitation, pulling the air as it pulls everything else down towards the center of the earth.

The higher we go, the less the pull. This is one reason, though not the only one, why air grows thinner or more "rare," as we say, as we climb a mountain or go up in an airplane.

THIN AIR OF MOUNTAINS

Besides the actual pull of the earth drawing the air particles downward, there is the great weight of the whole atmosphere above. Miles and miles of air overhead press mightily downward, packing tightly together the lower layers of air near to earth's surface. If thousands of bales of cotton-wool were piled into an enormous heap, the upper layers might be light and loose in their make, but the lower ones would be squeezed into a very small space by the pressure of the mass above. Without this pressure of the upper air the air down here would not be nearly so dense as it is; and, indeed, would not be fitted to support life. A man ascending a mountain or rising in an airplane leaves heavy layers of air below, and has an ever lightening weight above, so that the air around him becomes

constantly more thin, more difficult to breathe. This difficulty is felt severely by those who climb the greater mountains. Within certain limits of height the air is only more light and exhilarating, because a little less dense, than on



IMAGINARY CROSS SECTION OF THE EARTH

A represents the earth's silicate shell, 1000 miles thick, *C* is the dense metallic iron core, and *B* a transition layer made up of a mixture of silicate and iron. The earth's crust, represented by the outer black line, is a thin, crystallized layer of the silicate shell. Surrounding the earth is the atmosphere. The distance from crust to center of the earth is 4000 miles.

the plain. But as its rarity increases, the breath gets short, the heart's action is quickened, the sense of oppression grows painful. In the high flights of the airplane, the wise aviator takes oxygen to breathe in order to avoid suffocation or heart failure.

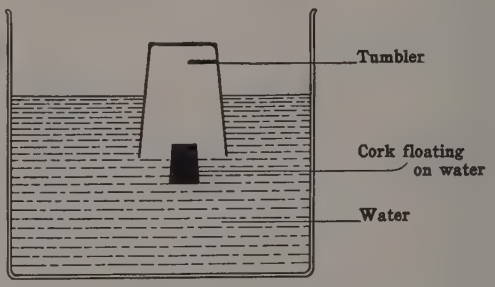
Men have, therefore, never been able to measure the depth of the air ocean in which we live. From certain effects of light and heat they can, however, guess at its depth. From the experiences of aviators at the highest points which they have been able to attain, it seems as though man could not breathe much higher.

WHAT IS AIR?

What is air? We talk about it as if it really were something, and yet we cannot see it. Air is a mixture of gases. All matter appears in three forms, — solids, liquids, and gases. Solids and liquids we can see, but most gases we cannot. It is easy, however, to prove that they are there. Think of the lighting gas which we burn in our houses. If our gas fixture leaks, we do not see gas pouring out, but we can smell it and feel it. No one would ever doubt it was there. We feel air most easily when the wind blows, for wind is only moving air. But even when the wind does not blow you can prove that air is everywhere even if it cannot be seen. Take an empty tumbler and hold it upside down. We call it empty, but it is really full of air — of invisible air. Then take a glass bowl half full of water and float a cork on it. Now gently press the tumbler down over the cork and notice the results. If there were nothing in the tumbler, if the tumbler were really empty, then the water would fill it full; but you can see that the water rises only for a certain distance, and no higher. There is air in the tumbler still. Now tip the tumbler sidewise a little, while it is in the bowl, and the air will come out in bubbles.

WHAT WE BREATHE

Of the gases which make up the air mixture, oxygen and nitrogen appear in greatest quantities, with four times as much nitrogen as



PROVING THE EXISTENCE OF AIR

If the so-called "empty" tumbler were not full of air, the water would rise to fill it.

there is oxygen. But the oxygen, though it is only one-fifth of the air, is a very important part to us, for man and animals require oxygen to breathe. Nitrogen is useful for the building of the bodies of both animals and plants. Farmers use nitrogen fertilizers on their land to give food to plants. Two other gases which appear in air are important. Carbon dioxide is

the gas formed when coal burns. Plants need this gas in the air to help them to make food. Water-vapor is the other gas. This water-vapor, that is, water in the form of a gas, forms clouds, rain, snow, and dew. Everything which goes to make up the air mixture is needed, you see, for our life.

AIR HAS WEIGHT

So evenly does air press on everything, that it was a long while before it was discovered that air had weight. Torricelli, a pupil of Galileo, found it out, and the story of this discovery is one of the most romantic chapters in the history of science.

Some gardeners, living in Florence, found that they were unable to pump water to a height of more than thirty-three feet into the air. This was reported to Galileo and Torricelli, and at first they could not understand it. The one thing everybody thought was sure about air was that "Nature abhorred a vacuum." By this was meant that Nature would never leave any space empty that she could fill. This was the principle of pumps. If air was driven out of a space, water would rush in. If water was poured out of a dish, air would rush in. Nature never meant to leave any space vacant, which is our word from the same Latin word, *vacuum*, which means "empty." When you learn more about Torricelli's work, you will see why this discovery of the gardeners, that water could not be pumped more than thirty-three feet into the air, seemed to go right against this old principle, which, after all, was true, that Nature did dislike or abhor a vacuum.

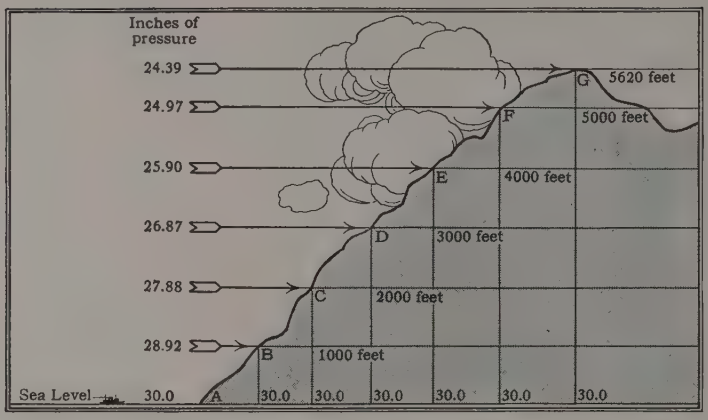
Torricelli had suspected for some time that air had weight. Now he said to himself, "Air must somehow be able to hold up a column of water thirty-three feet high, but no higher." A column of water thirty-three feet high was a pretty big column to experiment with; so he decided to take something much heavier than water and make his tests with that. Mercury (the silvery-looking liquid we use in thermometers) is one of the heaviest liquids, weighing about thirteen times as much as water. So Torricelli took an amount of mercury which would weigh about the same as this amount of water. If water could be pumped only thirty-three feet high in air, it ought not to be possible to drive a column of mercury more than thirty inches high. He took a long glass tube an inch square, closed at one end, and filled it with mercury. This tube he heated so as to drive out of it any air particles it might have absorbed by standing open to the air. Then he put his finger over the open end of the tube, to hold in the mercury, and turned it upside down in a cup partly filled with mercury. If he had held the tube upside down and simply taken away his finger, the liquid would have run out, would it not? It might be expected even now that it would run out of the tube into the half-filled cup. But it did not. Only a little mercury ran down, leaving a small empty space at the closed top of the tube; but there was still a column of mercury thirty inches high standing up in the tube. What held it up? The weight of the mercury was pressing down. Yet it did not fall. Something must be balancing that pull down by pressing up. The only thing that could be doing this was the air above the mercury in the dish. This must be keeping it from rising as high as it would if it let all the liquid flow out of the tube into the cup. So the air must be pressing down as hard, that is, be as heavy, as the mercury in the tube. Air must have weight.

TORRICELLI'S EXPERIMENT

HOW MUCH DOES AIR WEIGH?

The next question was how much weight. Again the mercury in the tube could help. It could be weighed. It weighed fifteen pounds. The tube was an inch square. Then the air must be pushing down on that square inch with a weight of fifteen pounds. It was pushing just as hard as it could. But air could press only fifteen pounds to the square inch. It could not hold up any more mercury. It had to leave the space empty.

For the first time in the world's history air had been weighed. Less heavy liquids were



HOW AIR PRESSURE VARIES WITH ALTITUDE

The higher up we go the less the pressure of the air becomes. For every thousand feet in altitude the mercury in the barometer drops about an inch. Thus the height of a mountain can be figured from the barometer.

tried, and they stayed higher in the tube; heavier ones did not give so tall a column. But for a square-inch tube the weight held up was always the same. We do not use the word "weight" in speaking of air so much as we do the word "pressure," because weight usually means to us pressing down. Air presses not only down, but up and on every side. If this were not so, we should be crushed by it. Think of a weight of fifteen pounds pushing down on every square inch of your head, with no upward push to balance it. But air pushes in every direction. It is not only above us, but about us; not only outside of us, but inside.

You can prove this in a simple way: Put a piece of paper over the mouth of a bottle full of water. Turn the bottle carefully upside down; the water will be held in it by the upward pressure of the air on the surface of the paper.

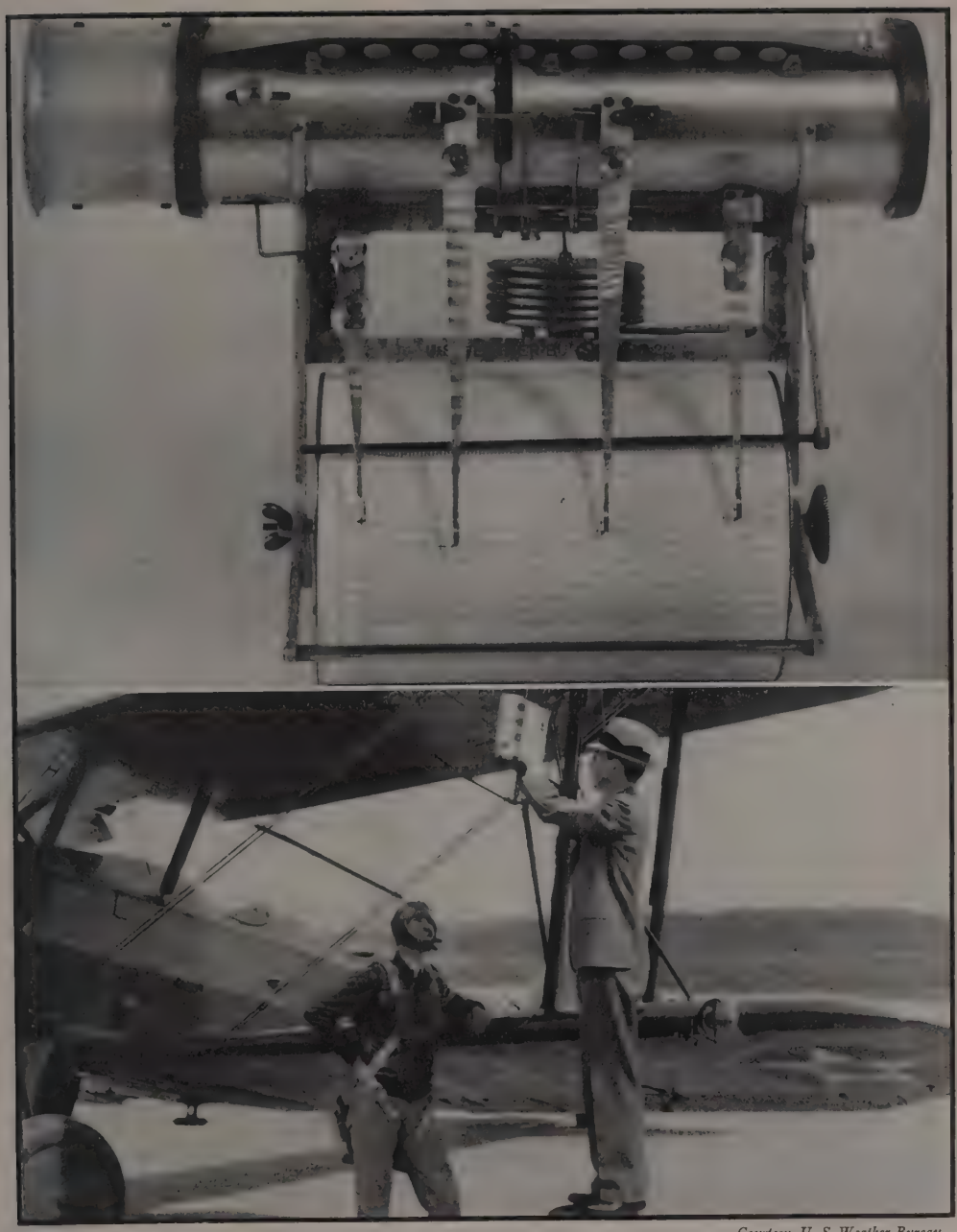
FINDING OUT HOW HIGH A MOUNTAIN IS

The pressure of air is not always the same. It is different in different places. The mercury tube had been tried at sea-level, and had stood about thirty inches high. Next it was tried on a mountain top. The column was lower. The air was not pressing so heavily; it was lighter. This we can understand very well, for we know there was not so great a mass of air pressing down on it from above, and besides the pull of the earth was not quite so great. The height of the column has been measured for every difference in distance above sea-level. When it had been carried about a thousand feet above sea-level, it was only twenty-nine inches high. Up another thousand feet it had lost another inch.

Do you see how this discovery could be turned round to measure the height of mountains? The mercury column measures the weight of the air above you. It falls about an inch for every thousand feet you climb. Then, if your column has fallen about an inch, you have climbed to a point about a thousand feet higher than the one where you read it last. If it falls half an inch, that will mean five hundred feet. In this way the heights of mountains are roughly measured.

A BAROMETER

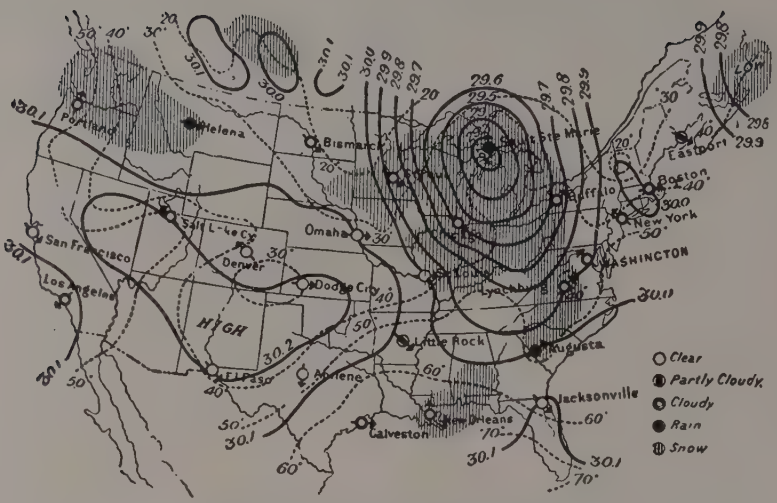
Do you know the common name for this mercury tube? A *barometer* — that is to say, a weight-measure. Every day when you read the weather prediction in the newspaper, you are reading what this mercury tube has told. In every station of the United States Weather Bureau, and in many private houses, you will see barometers made after just this pattern. They are of use in telling what the weather is going to be, because the weight of air is slightly different with different weathers, as well as at different heights.



Courtesy, U. S. Weather Bureau

HOW THE CURRENTS OF THE UPPER AIR ARE TESTED

The upper picture shows a kite meteorograph. As the paper-covered drum slowly turns, four pencils trace a continuous graph of temperature, height, humidity, and wind velocity. In the lower picture an aero-meteorograph is being attached to the wing of an airplane. Sounding balloons are also used to carry meteorographs aloft, sometimes reaching heights of twenty miles before they burst and allow their instruments to descend by parachute. Some meteorographs do not use the drum recorder but transmit their records directly to the ground station by means of a small automatic radio.



SECTION OF A GOVERNMENT WEATHER MAP, SHOWING THE HIGH AND LOW PRESSURE IN DIFFERENT SECTIONS OF THE UNITED STATES

THE ANEROID BAROMETER

Besides the mercury barometer, there is another type, the aneroid ("without liquid"). The aneroid barometer consists of a metal box or series of boxes from which the air has been taken. Any change in the outside pressure makes a change in the distance between the top and bottom of the box. This motion of the top and bottom is carried to a hand or pointer on a dial which may be made to read in inches of mercury just as the mercury barometer does. An aneroid barometer is light and easy to carry and has no liquid to spill; hence it is commonly used by mountain climbers and aviators to measure altitude. When so used it is called an altimeter and the dial is made to read directly in hundreds and thousands of feet above sea level.

WEATHER FORECASTING

In fine weather the mercury in a barometer usually stands high. In stormy weather it usually drops. Look at a government weather map and see how it reads. There will be places where the word *low* is printed; then in other parts, you see the word *high*. Those are barometer records. The central weather bureau at Washington receives reports, from two to four times daily, from more than two hundred observers stationed in all parts of the United States, from ships at sea, and from the weather bureaus of Canada, Mexico and the Caribbean republics. These reports give barometer readings, wind direction and velocity, temperature, and relative humidity. From such reports they are able to make up a daily weather map for the entire country. Areas where stormy weather may be expected will show on the map as areas of low barometer. By following their progress weather predictions can be made. Suppose, for instance, that the barometer in the country around Omaha is low on Monday and by Tuesday the low pressure area has traveled eastward to Ohio; then the weather bureau tells New York to look out for stormy weather on Wednesday. The weather bureau also maintains a special service for aviation, keeping pilots informed concerning flying conditions.

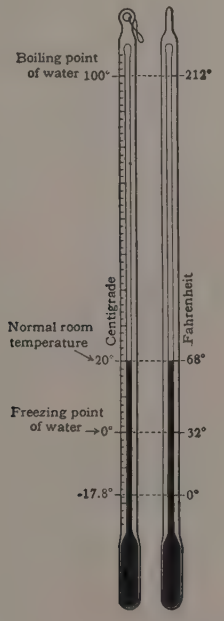
THE THERMOMETER

Another mercury instrument, the thermometer, measures the temperature of air for us. Heat expands most things. It drives apart the particles of which they are made. Mercury is very sensitive to changes of heat or cold. So we use it for our thermometers, our heat meas-

ures. A thermometer is a glass tube, closed at both ends, ending below in a glass bulb. It holds enough mercury to fill the bulb and part of the tube, the space above being emptied of air. When the air is hot, mercury feels it very quickly, and swells in size, so that the slender line of it in the tube rises. When the air surrounding the tube is cold, the mercury is chilled. It begins to shrink, and sinks lower in the tube. So we have this simple way of measuring the temperature.

FAHRENHEIT AND CENTIGRADE

In 1720 Gabriel D. Fahrenheit, a German, devised the mercury thermometer which we use. He put it into melting ice and made a mark on the tube just where the mercury stood, calling this the freezing point; and then into boiling water and made another mark where the mercury stood then. This was boiling point. When you study physics you will find out why he numbered the first mark thirty-two, and the other two hundred and twelve; but he did, and divided the distance between his two fixed marks into one hundred and eighty equal parts, which he called "degrees." His thermometer was used in England; the English brought it to America; and we use it to-day. But in Europe they use another scale of degrees, which was invented in France about a hundred years ago. Ours is the Fahrenheit thermometer, named for the man who invented it. Theirs is the centigrade, from the Latin word *centum* for "one hundred," and *gradum* for "degree." It is so named because it has one hundred degrees, freezing point being at zero, and boiling point at one hundred. Of course you will pronounce the name Fah-ren-*hite*, not Fah-ren-*heat*.



CENTIGRADE AND FAHRENHEIT THERMOMETERS

HOW AIR GIVES UP ITS WATER

There are two questions we ask about the weather. The first is, "Is it warm or cold?" the second, "Is it wet or dry?" It does not take a very wise person to know that there is often water in the air. As a matter of fact, there is always water in the air. But how does it get in and out? Bring a tumbler of ice-cold water into a warm room, and watch what happens. The outside of the glass will soon be covered with a fine film of mist. In a little while tiny drops of water will form out of this film, and will go on growing, until perhaps some of them unite and trickle down the sides of the tumbler.

You may have noticed, too, that on very cold nights the windows of sitting-rooms or crowded public halls are found streaming with water on the inside.

Where does this moisture come from? It certainly does not come out of the glass. It comes from the water-vapor in the air. When the invisible vapor dissolved in the air becomes visible, as in mists, clouds, dew, or rain, it has been *condensed;* that is, pressure has pushed the particles of which it is made closer together. Condensed milk is milk which has been changed to the thickness of very heavy cream. Liquids are thicker, more dense, than gases; so a gas must always be condensed to become a liquid. The film of mist which forms on the tumbler is really dew, just such as we see at night and morning upon grass, leaves, and stones. After the sun has set, the grass is cooler, and the air gives it some of its water.

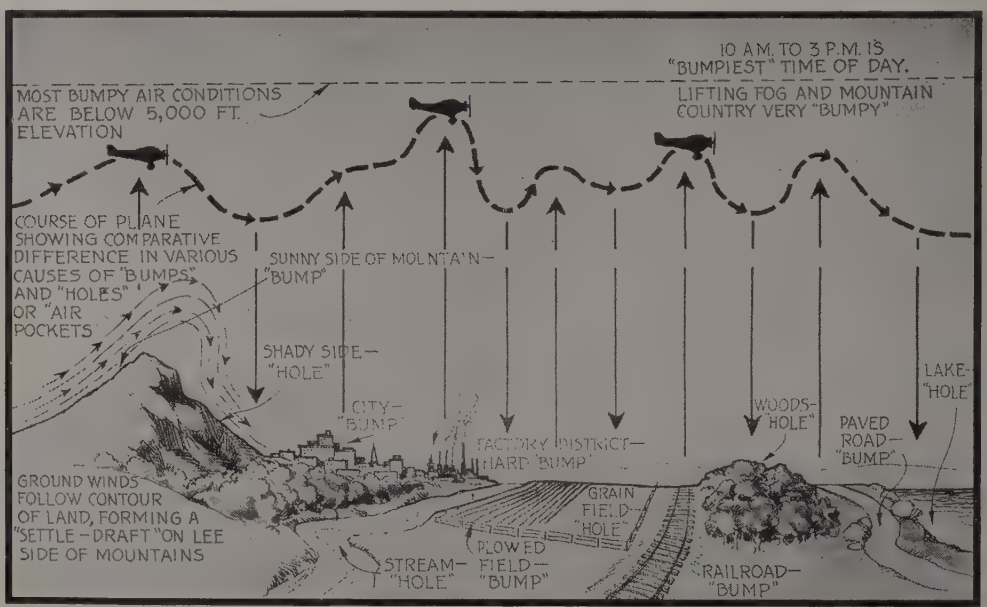
HOW AIR TAKES UP WATER

We need only to think of our own weather, with its damp days and dry days, to know that the amount of water-vapor in the air is always changing. It varies with the temperature. Warm air can hold more moisture than cold air. You can show this in a simple way. In breathing, you give out at each breath a quantity of water-vapor; when the air is warm, this invisible vapor, as soon as it escapes from you, mixes with the outer air, and is kept dissolved there. But if you cool the breath as it leaves your mouth, the vapor becomes visible moisture. Take a mirror, for example, or any other cold surface, and breathe on it; the vapor from your lungs at once shows itself in a film of mist upon the glass, because the air touching the cold surface is chilled and cannot hold so much vapor, part of which is condensed. In winter the cold air around you at once condenses this vapor as it comes from the mouth, and forms the fine cloud or mist which appears with each breath you give out.

As air cools, its power to hold vapor grows less, and it gives out the moisture it cannot hold. Then it grows warmer again, and does not have all the vapor which it can hold. How does it get it back? If you pour a little water into a plate, and set it down in the open air, you will notice, in the course of a day or two, that there is less water in the dish than when you set it out. The air has drunk up part of it, and will drink up the whole if the water is allowed to stand long enough. We say that the water has *evaporated*, that is, passed off into vapor. Earth and air are both dependent upon water.

AIR A GREAT WATER DRINKER

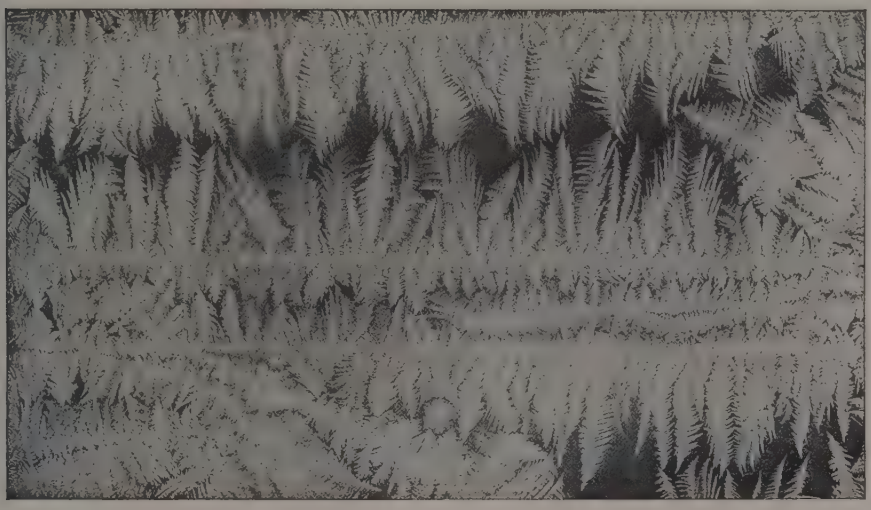
Air wants as much water as it can hold, so on a dry, bracing day water will evaporate very fast, because the air wants it and has room for it. On a damp day, however, when the air has about as much vapor as it can hold, evaporation is quite feeble or stops altogether. That is why housekeepers find so much difference between days, in the ease with which they can


10 A.M. TO 3 P.M. IS "BUMPIEST" TIME OF DAY.
MOST BUMPY AIR CONDITIONS ARE BELOW 5,000 FT. ELEVATION
LIFTING FOG AND MOUNTAIN COUNTRY VERY "BUMPY"
COURSE OF PLANE SHOWING COMPARATIVE DIFFERENCE IN VARIOUS CAUSES OF "BUMPS" AND "HOLES" OR "AIR POCKETS
SUNNY SIDE OF MOUNTAIN— "BUMP"
SHADY SIDE— "HOLE"
CITY— "BUMP"
FACTORY DISTRICT— HARD "BUMP"
WOODS— "HOLE"
PAVED ROAD— "BUMP"
LAKE— "HOLE"
GROUND WINDS FOLLOW CONTOUR OF LAND, FORMING A "SETTLE-DRAFT" ON LEE SIDE OF MOUNTAINS
GRAIN FIELD— "HOLE"
PLOWED FIELD— "BUMP"
STREAM— "HOLE"
RAILROAD— "BUMP"

Courtesy of Popular Science Monthly

WHY AN AIRPLANE FINDS THE AIR "BUMPY"

"Bumps" in flying are caused by rising currents of warm air. "Holes" in the air are produced by downward currents of cool air.



CRYSTAL FROST ETCHINGS

Air containing water vapor has been cooled. Cold air cannot hold as much water as warm air. The extra moisture is given up on the cold glass. The temperature is low enough for this water to change to frost.

have their clothes dried. On some days the air is busy drinking up vapor everywhere, and then the clothes dry quickly. Such is especially the case when the sky is clear and the wind blows, because every moment a fresh quantity of air comes in contact with the clothes, carries off some of the vapor, and passes on to make way for fresh supplies of thirsty air. On other days, the air can hardly hold more vapor, and the clothes are found at the end of the day to be almost as wet as when they were hung out in the morning.

HOW CLOUDS ARE MADE

This taking up and giving out of moisture by our air blanket is the explanation of clouds. Clouds are water-vapor cooled into liquid form. Sometimes they are a thin mist. When vapor condensed on the outside of the glass in the warm room, it did not at once become running water. There was a fine mist on the glass before the drops of water appeared. This mist was made up of tiny particles of water which ran together to make drops. When a warm, moist cloud blows over a cold mountain top, there is not instantly a shower of rain. Yet the air is cooled, so that it must give out some of its vapor. This becomes a mist, which seems often to rise from the ground, and which shapes itself to the form of the ground, as if it were a sort of fleecy cap drawn down over the mountain's head. Mountains are often covered with a mist cap in the morning. As day advances, the ground, warmed by the sun, no longer cools the air. The air can drink up the mist, and the mountain is clear. Then as night comes on the ground grows colder, cooling the air about it, and the mountain pulls on its mist cap again.

Cold air, as well as cold ground, condenses the moisture of the warmer air into vapor. If you watch what goes on in the sky, you may often see clouds in the act of forming. At first a little flake of white appears. By degrees this grows larger and other cloudlets arise and flock together, until at last the sky is quite

STORM CLOUDS

When clouds like these appear, it means that an excess of moisture is gathering in the air.

CUMULUS CLOUDS

These clouds usually foretell fair weather, but they may be the beginning of a thunderstorm.

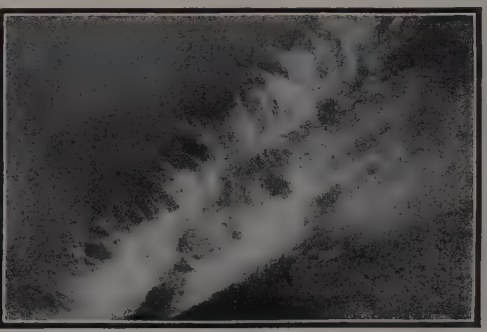
overcast with heavy clouds. On a summer morning the sky is often free from clouds. As the day advances, and the earth gets warmed, more vapor is raised; and as this vapor reaches the higher and colder parts of the atmosphere, it is chilled into the white, fleecy clouds which you see forming about midday and in the afternoon. Towards evening, when less evaporation takes place, the clouds cease to grow, and gradually become smaller until at night the sky is quite clear. They have been dissolved again by descending and coming in contact with the warm air nearest to the earth. Again, you have often noticed that clouds move across the sky. They are driven along by upper currents of air, and of course the stronger these currents are the faster the clouds travel. In this way the sky is sometimes completely overcast with clouds which have come from a distance.

CLOUDS AND THEIR HEIGHTS

Watch the sky and you will soon be able to recognize several kinds of clouds. Highest of all are the *cirrus* clouds, named from the Latin word for a curl of hair, because they are thin, feathery, curling wisps of white vapor. They are often five or six miles up in the air. Next below them are the *cumulus* (Latin for "heap") clouds, great, rounded, billowy masses, looking like mountains in the sky. They are formed by the rising of warm air from the earth, and are usually from half a mile to two miles up. Cumulus clouds often develop into storm clouds, which are also called

STRATUS CLOUDS

Rain follows these clouds and the temperature rises suddenly.



CIRRUS CLOUDS

These clouds are the signal for a storm, and rain or snow may follow after some time.

Fairchild Aérial Surveys, Inc.

AN AIR VIEW OF CLOUDS

Flying over Kentucky.

nimbus clouds. Low in the sky, especially in stormy weather, you will see the *stratus* clouds, lying in layers across the horizon. When they are so very low that we are walking around in them, we call them fog.

RAIN AND SNOW

When the particles of water mist from the clouds condense into big drops of water, which are too heavy for the air to hold up, we have rain. Sometimes in cold weather we have snow instead of rain.

Snow is not frozen rain. It falls directly as snow from snow clouds. In winter the frozen clouds lie at a much lower level than in summer. Snow clouds, like mist clouds, when they grow too heavy, have to part with some of their substance, which falls to the earth in white flakes instead of water drops. Much more than mere weight, however, is involved in a fall of snow.

RAINFALL

A certain amount of rain is necessary to raise crops. The U. S. Weather Bureau catches rain and measures it by means of an instrument called a "rain gauge." This consists of a big funnel with a long stem. The depth of water in the stem is measured in inches. Snow is allowed to melt and is measured in the same way as rain. Ten inches of snow is about the same as one inch of rain. One inch of rain falling on an acre of land amounts to 27,000 gallons of water. The government has been measuring rainfall for years.

There is no place on earth where it never rains. Even the Sahara Desert is not without rain. The dryest place in the United States is the Mojave Desert of California. One half of the land area of the earth gets less than 20 inches of rain a year. The land must therefore be irrigated for the raising of crops. The story of methods of irrigation from the simple ditches of ancient times to the elaborate systems of the present day, by which great arid districts are being reclaimed, is told in Volume Four. Our western seacoast has abundant rain; just east of the Rockies and Sierras there is very little. Can you tell why? The greatest rainfall in the world is 500 inches a year in India.

WHY SNOW IS BEAUTIFUL

Snowflakes are made of the most exquisite ice crystals. The minute needles group themselves into beautiful star-like shapes, always six-pointed. Many substances, when changed from a liquid into a solid, will crystallize into delicate and beautiful forms, and it is notably so with water. When sometimes water vapor freezes into snow, the snow crystals are always formed of six-pointed stars or plates. That it is so we can see with the microscope; but why it should be so we do not know. If very large flakes come down, they are caused by the union of smaller flakes. The drier the air, the smaller and harder will the flakes be, for they cannot stick together unless they are a little damp. A handful of snow brought indoors soon melts into water, which, on further exposure to the air, evaporates.

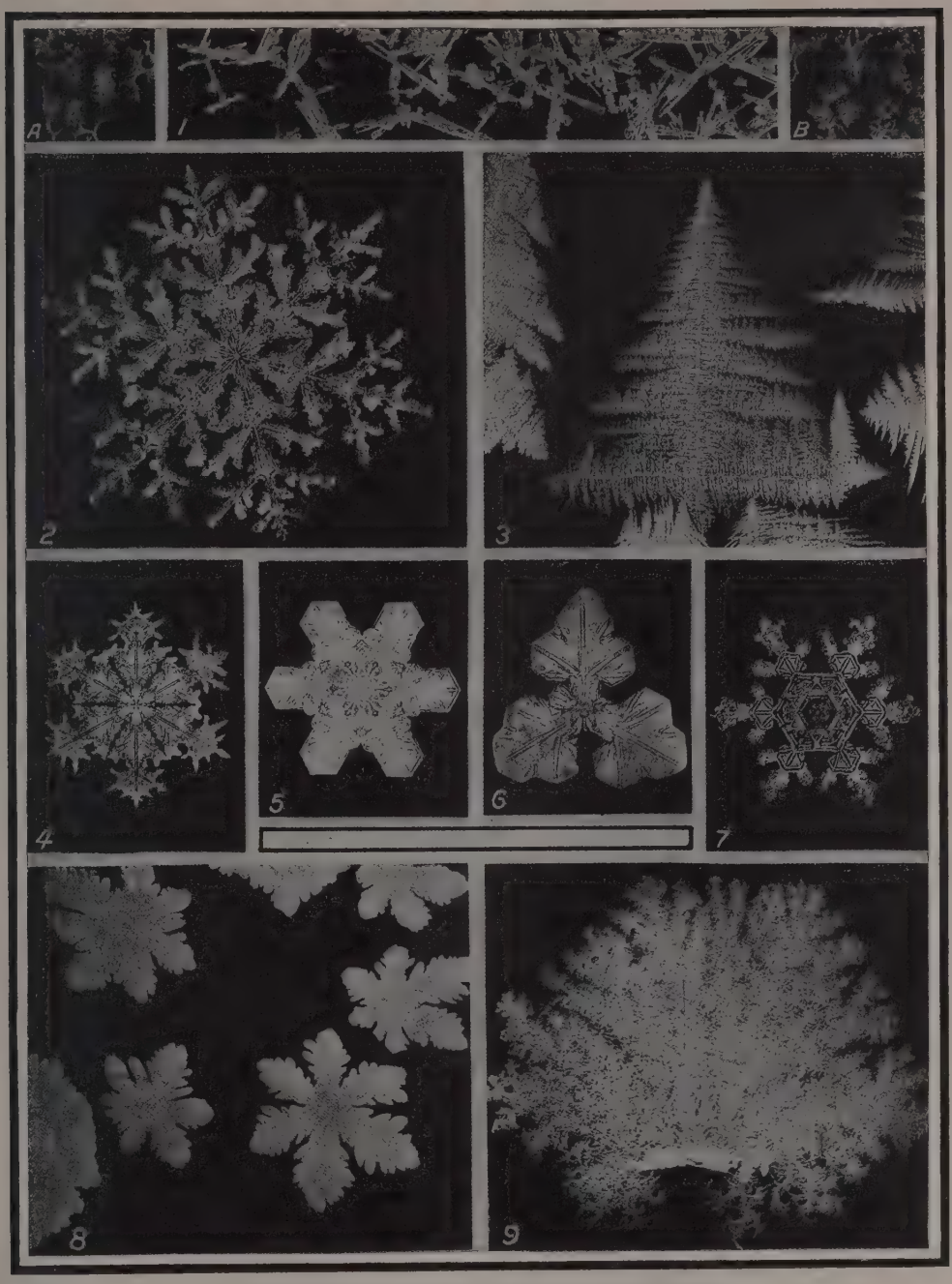
HAIL, SLEET, AND ICE

Besides rain and snow, the moisture of the air takes sometimes the form of hail, which consists of little lumps of ice, like frozen rain, and of sleet, which is partially melted snow.

On a frosty night pools of water are covered with a hard, transparent crust, which we call ice. Brought into a warm room, it soon melts into water, which may easily be turned by heating into steam or water-vapor that we can see, but is quickly absorbed by the air of the room. So rain, snow, ice, hail, sleet, mist, and steam are the liquid, solid, and gas forms of this one substance whose common form is water.

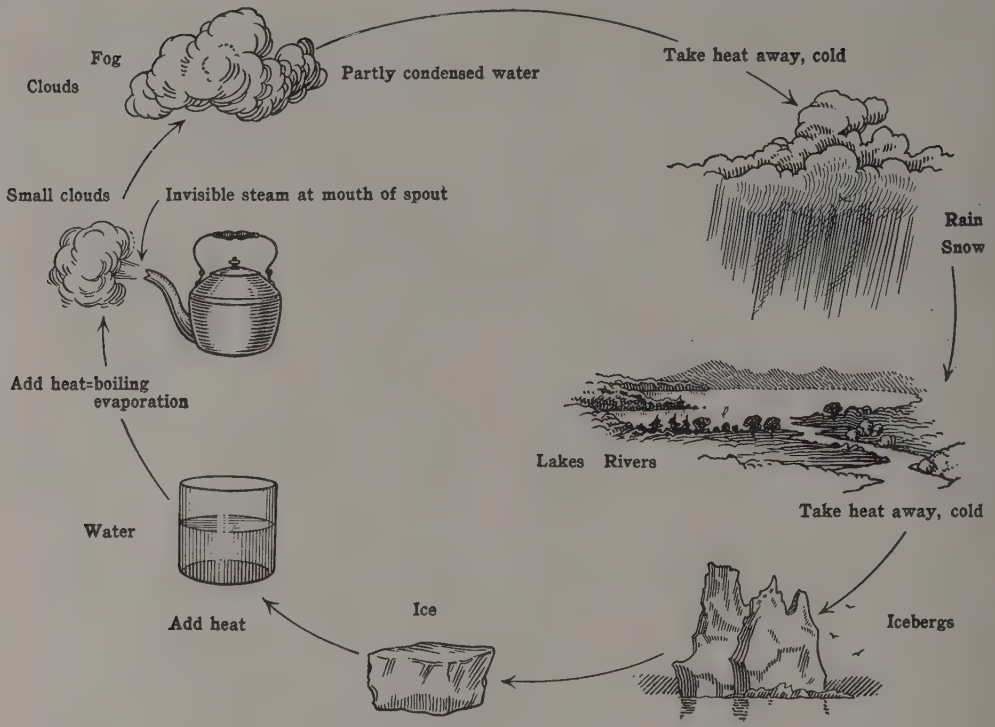
WHAT WE OWE TO AIR AND WATER

This exchange of water between earth and air is one of the best things in the world for us. It is really necessary in order to make the earth a fit dwelling place for man. Just as the circulation of the blood keeps our bodies alive, so this circulation of water keeps life on earth. It mixes and washes the air, clearing away impurities, such as those which rise from the chimneys of a town. It moistens and quickens the soil, so that trees and plants and flowers can grow from it. It supplies springs, brooks, and rivers. In short, it is the very mainspring of all the life of our earth.



SNOW CRYSTALS, IN THEIR VARIED AND EXQUISITE FORMS

A and B. Ice crystals. 1. Sleet, sharp and stinging. 2. A diamond pendant. 3. Frost design "from the land of the pointed firs." 4, 5, 6, 7. Snow crystals. 8. Snow leaves. 9. Hoar frost.



WATER AS A TRAVELER

Have you often wondered why things do not have an end? Nature has arranged for many events to go in circles (cycles), and thus they have no end. Water is a great traveler but its journeys are always in a circle. This is called the "water cycle." As you study science, see if you can discover other cycles.

WHY DOES THE WIND BLOW?

The air in which we live is never at rest. Streams of air flow hither and thither, making winds from the north and east, winds from the west and south, winds from every point between. Some change from hour to hour. Others flow in the same direction for months. Some are hundreds of miles wide. Others may be measured by yards. There are great rivers, as well as tiny brooks, of moving air in this air ocean; and wind is nothing more nor less than moving air.

But why should air move at all? We can picture to ourselves a great ocean of air in perpetual rest, a world without winds, an atmosphere without movement. Such a world with such a blanket of air might possibly exist under certain conditions; but it would have to be very different from ours, a world not spinning upon its axis day and night, a world without varieties of heat and cold, of climate and weather.

Wind is caused by change in temperature. When any part of the earth's surface becomes heated more than other parts near it, the air over that part gets warmer too. But when air is heated it expands; its particles get farther apart, it spreads out, and so becomes less heavy. Then it rises, pushing the air over it away. At the same time the colder, denser air from the cooler parts of the earth rushes in to take its place. This is the way winds begin. They are named, as you know, from the direction in which they come. Because the northern part of the world is usually colder, a north wind will probably be cold, and wind from the south will

be warm. It all depends, not as we think on what part of the sky they come from, but what temperature of earth they have had under them, and how much water-vapor they have picked up.

CHART SHOWING THE WORLD WINDS

WINDS

The fastest wind recorded by the U. S. Weather Bureau is 102 miles per hour. A wind 39 to 54 miles per hour is called a gale, and may do slight damage to property — break limbs from trees, remove slate from roofs, etc. A wind from 55 to 75 miles per hour is a hurricane, and is very rarely experienced. It does considerable damage.

WORLD WINDS

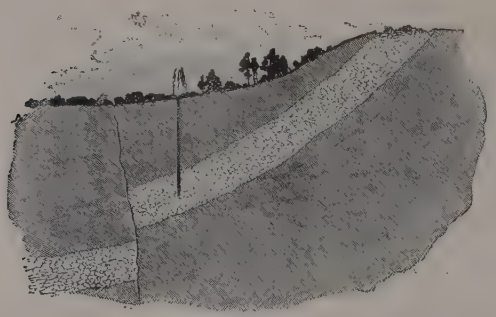
The geographies tell us about the north and south poles, and about the equator, that line which we imagine running round the earth halfway between the poles. You have also heard about the zones or belts of heat and warmth which run round the globe. But what you have read of the movements of earth and sun will make you understand more about the reasons for these zones. The belt right round the equator gets the rays straight from the sun; so it is hot. The temperate zones get them more or less slanted, and for greater or less lengths of time; so they have warm summers and cold winters. In the northern zones, the sun shines low in the sky part of the year, making this region very cold.

These things are familiar to us; but the question is how they affect the winds of the world, which we have found to depend on the heat or cold of the ground beneath them. They make great world winds which blow in the same general direction all the time. The warm earth round the equator makes a belt of warm air encircling the earth for a wide space. This air is light and rises, flowing naturally in a very high stream or current towards the poles, but being chilled and condensed as it travels along. Meanwhile the cold air rushes in from the cooler regions to the north and south. These surface winds flowing in towards the hot countries are the trade winds. Right at the equator where the opposite kinds of winds meet — one low current of cold air rushing in and the other high current of warm air rushing out — there is a still belt, which has long calms and much rain. The air currents are fighting with each other. This belt of "equatorial calm" used to be very much dreaded by sailing vessels, which depended on the wind to carry them and would sometimes have to wait weeks for a breeze. But right above and below this belt were the belts of the trade winds, so named because they helped the world's trade when it was carried on by sailing vessels. These winds blowing in from the poles toward the equator could always be counted on to give the vessel a lift.

ROCKS THAT STORE WATER

Great quantities of water are often in the solid part of the earth.

There are other great wind belts, but these are the most important. They are not always at just the same place on the globe, and they do not blow straight from north or south. Can you think why that is? The movement of the earth. We are always being brought back to



WATER TRAVELING UNDERGROUND FROM HIGH LAND MAY BE FORCED UP THROUGH A ROCK FAULT TO FORM A SPRING OR THROUGH A DRILLED SHAFT AS AN ARTESIAN WELL.

that, until we begin to see what a difference this one fact makes in our understanding of things which take place on the earth. If the earth stood right up and down, the currents would blow due north and south. Now they are shifted by the spinning motion of the earth, and by the speed at which it turns in different places, so that they blow to the northeast or to the southwest.

These are not all the wind movements. Upper currents drop to the surface, and surface currents rise many times in the long journey of these world winds. But it all goes to show how the spinning earth pulls its air blanket round with it, and how the air blanket tries to fit itself to the earth.

WHAT BECOMES OF RAIN

Just as water is always being passed from air to earth and back again, so it is passed from one part of the earth's crust to another. The ground needs a good deal of rain to keep it moist. But it cannot always take it up as fast as it falls. Then we have floods in our rivers and deep mud in our roads. But in a few days these disappear. The ground has taken the water and stored it away. Some kinds of soil let water through easily. They are loosely put together. A bed of sand will dry off very quickly. It has let all the water run through. But clay is very closely made and will hold water a long time. In regions where the soil is of a kind to hold water well, there will be many springs near the surface, ready to bubble out when they find an opening. In others we have to dig wells deep down into the earth to reach the great underground water supply which the rocks are holding in their basin.

This underground water supply helps also to keep the rivers full. Away up in the mountains there will be two or three springs. Water will flow from them down the mountain side, wearing a place for itself as a tiny stream. Then it will meet other streams. Other springs will flow into it, and down on the lower lands there will come to be a great, wide river, fed by many streams. The earth has given out the water which came down in rain and was stored. Air will pick up some of it and give it back, and so the circle will begin again.

GLACIERS AND ICEBERGS

Rain flows down from the mountains in rivers, but what about the snow? How do the mountains get rid of the extra loads which every winter puts on their backs? Below the freezing line, where it is warm enough for snow to be melted into water, it too can be taken care of by rivers and springs. But above the freezing line, where snow never melts except the tiny layer which is right on the surface and catches the rays of the sun, this extra amount must be taken care of in some other way. Then we have glaciers, rivers of ice, pushing slowly down the mountain side into the valley. As it travels down it loses much of its surface by melting, but the central part stays frozen for months and years, creeping inch by inch down the valley. When an ice river starts from the cold north, and reaches the sea, it breaks up into icebergs, which float off to the south.

HOW DO WE KNOW THAT THE EARTH IS ROUND?

If a friend asked you to tell how you knew that the earth was round, what would you say? You know it is. You have always been taught so. You have seen globes showing just how

it looks. You even know that people go round it. But if anybody came to you and insisted that the earth was a flat plain and said you had been taught wrong, how could you prove you were right?

If you were by the seashore, or by a great lake, you would take him out and ask him to watch a ship as it came in sight at the edge of the horizon and then gradually approached you. If the earth were flat, as soon as the ship appeared on the horizon, you would see the whole of it. But you see the topmasts first, or, if it is a steamer, you see the top of the smoke-stack with the smoke pouring from it. Then, as it comes nearer, you see the sails and the upper decks, and then at last the hull of the ship comes into sight. This is what happens if you look at something coming up over the top of a hill or any curved surface. Then, too, the ship always looks like this when it is coming towards us, no matter whether it comes from north or south, east or west. So we judge that the earth does not bulge out in only one place, but that it is evenly curved, or round.

If you lived where there was no great body of water, you would have to prove your point by the horizon line. It is because of the roundness of the earth that our outlook on a plain is so soon shut off by this line, which looks as if it were the meeting of earth and sky. If the earth were flat, we should be able to see much farther. Again, this horizon line is a circle. This is not absolute proof that the earth is round, for if you happened to be standing in the center of the great flat plain which men used to think was the earth, you would have a circle for the horizon line. But suppose you went off to the edges of the world. Then the line ought to be uneven. Our horizon line is a circle at any place on the earth's surface. Then, too, the eclipse of the moon is caused by the earth's shadow falling on the moon. This shadow can at such times be seen by us. It is always round. So the earth must be round.

HOW DO WE KNOW THAT THE EARTH IS NOT PERFECTLY ROUND?

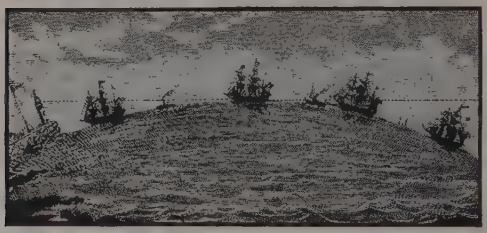
Yet you must remember to tell your friend that the earth is not perfectly round; it is not a true sphere, like a ball; and how do we prove that? We can guess it easily enough by the roughnesses of the earth's crust, the mountains and valleys and sea basins; but we can prove it by carrying something from the equator to the north or south pole, or as near as we can get, and weighing it in each place. At the poles it will weigh a little more than at the equator. The poles must then be nearer the center of the earth where the pull of gravity begins. As a matter of fact it has been proved that the earth is slightly flattened at the poles, as though you took a rubber ball and pressed it gently on two opposite sides. The earth's

THE GORNER GLACIER IN THE SWISS ALPS

thickness at the equator is 27 miles more than at the poles.

LAND AND WATER

How queer it would be if the land and water were equally scattered over the globe! We should have to spend much more of our time



SHIPS SHOWING A ROUND EARTH

An exaggerated view of the curve of the earth's surface.

traveling on the water than we do, for the land part is only one-fourth of the water part. If this land part were scattered equally over the water surface, we should all be living on tiny islands in the midst of great stretches of water. But fortunately the land is grouped into great sections which we call continents, and the waters are massed into seas. The sea runs up into the continents in great gulfs, and the land reaches out into the sea in capes or separate islands; but on the whole the land is crowded together, and the water together. The queer part of it is that the land is almost all pushed up to the top of the globe, crowding towards the north pole in an irregular kind of ring, so that nearly all the land is collected in one hemisphere and nearly all the water in the other. Why this is so we do not know, though men have given all sorts of reasons. Some say it is because of the tip of the earth; the water is lighter and the sun and moon can pull it easier than they can the land. Others think it is because the cooling took place in a certain fashion, making the great ocean beds towards the south, because there was more cold there, and so more shrinking. It is an interesting fact that the bottom of the ocean in its deepest parts is from five to six miles below the sea-level, while the highest mountains in the world are about the same height above sea-level.

THE EARTH'S ATMOSPHERE

Man has begun recently to explore the air blanket immediately surrounding the earth in his airplanes and with his balloons. How small a portion of this ocean of air he is able to explore in this way is graphically shown in the chart on the opposite page. Study it carefully, noticing the location of clouds, of twilight, of the "blue-sky" limit, and of the Aurora. The lowest layer shown there, the troposphere, extends, in our latitudes, to a height of about seven miles above sea-level. At the equator it extends to about ten miles and at the poles only to about five miles.

Within the troposphere the temperature decreases as height increases. Ordinary clouds and storms are confined to this layer.

In the next layer, which is called the stratosphere, the temperature remains the same, regardless of height. The stratosphere has been penetrated by sounding balloons, also by several manned-balloon ascensions and airplane flights, and is the subject of the scientists' special, present interest.

The third layer takes its name of "hydrogen-

THE LAND AND WATER DISTRIBUTION OVER THE TWO HEMISPHERES

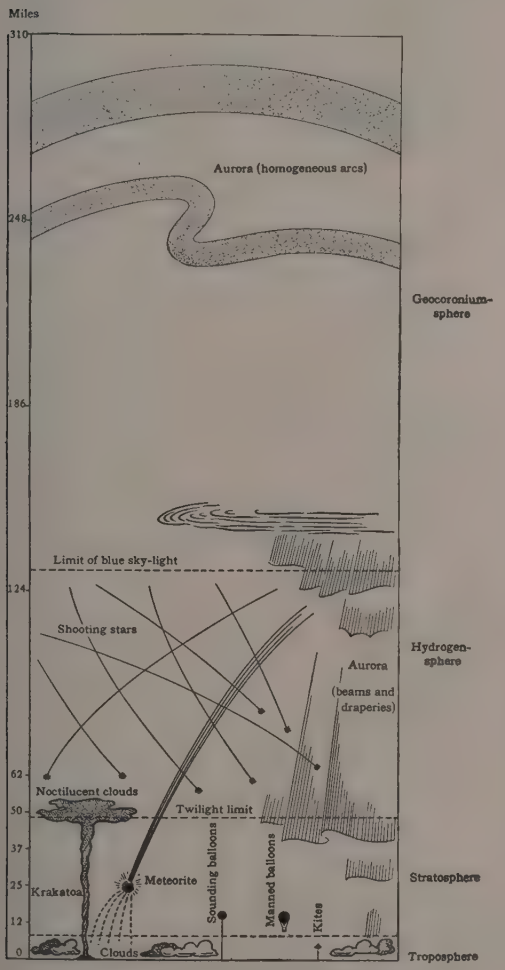
Notice how the land is crowded around the North Pole.

sphere," from the fact that it consists chiefly of hydrogen. The noctilucent clouds at its lower limit are sometimes seen on summer nights, shining by reflected sunlight. Because they have been observed after eruptions of Krakatoa, they are commonly explained as resulting from volcanic eruptions on the earth.

Above the hydrogen sphere is thought to be a layer of geocoronium, a gas lighter than hydrogen. Little is known about this sphere.

THE SCIENTIFIC NAME FOR MOTHER EARTH'S DIARY

Now would you like to know the name that students give to this story of the earth crust and its air and water blankets about which you have been reading? They call it "physiography"; and what does that mean? *Physio* is from the Greek word for "Nature," and *graphy* means "writing"; *physiography*, "Nature's writing," the diary which Mother Earth has kept and written on her surface for us to read.



WEGENER'S PROFILE OF THE ATMOSPHERE

AIR AND ETHER MESSAGES

MESSAGES WHICH AIR BRINGS US

AIR is man's most faithful and devoted messenger. It is only recently that man has learned to use electricity in sending messages by telegraph, telephone, and radio. But air has been used by him to send and receive messages from man's very beginning. Sound is one of them. The world would be absolutely still if it were not for air to bring the messages of sound to our ears. Light and heat are two other messages. Some kinds of light and heat could come to us anyway without air; but they would be very different and very much less pleasant if air did not take them into its kindly keeping for a time and bring them to us in just the way we can bear them. So we cannot close our story of earth without giving a little time to these wonderful messages which air brings to us earth dwellers. Of course, if it were not for air we should not be able to live on the earth at all; so that our debt to air begins with life itself.

After reading as far as we have in the books of the heavens and the earth, we hardly need to be told that there are two main sources of heat in the world: the sun and the inside of the earth. There are other ways in which heat is made than by the sun and the earth. We can make heat by rubbing two hard substances together, or by putting certain liquids or gases together. These are the ways the sun and earth make their heat, by friction, or shrinking, or by some sort of chemical action. We make heat in our bodies — what we call animal heat — by eating food which will start chemical action. But most of our heat comes from the sun, and all the heat that comes from the sun is brought to us by the air, which both serves and shields us.

HOW HEAT IS GIVEN OUT

How does the sun seem to give out heat and light? By rays, does it not? We talk about the sun's rays as being very bright or very hot, and we go into our houses and put a roof between ourselves and these rays when we want to keep cool. Because heat and light are given out from hot or burning bodies in what we call

"rays," that is, lines coming out from a surface in all directions, we say that heat and light come to us by *radiation*, that is, the giving out of rays. Notice the word, for you will meet it often. We have heat radiation and light radiation, and scientists have also discovered other forms of radiation such as radio waves, X-rays and cosmic rays. They wonder if radiation is not one of the strongest forces working against gravitation, so that while gravitation is trying to hold things together and pull them towards a center, this great opposite force is also hard at work, sending out rays not only of light and heat, but many other kinds of which we do not know because we cannot see or feel them.

WHAT AIR DOES WITH THE SUN'S RAYS

We can imagine the sun's rays traveling along through space towards the earth until all at once they strike the thin upper layer of our one-or-two-hundred-mile-thick air blanket. What will happen then? What happens always when something comes between the object that is giving out heat and the object that is receiving it? Try for yourself with a fire. You sit before an open fire and the heat pours out from the coals until your face begins to burn. You are getting the rays of heat too directly for your comfort. What do you do? You put something between you and the fire. Either you hold up a screen before your face, or you move to the other side of the room; that is to say, you put more air between you and the fire. The air takes up some of the heat, so you do not get as much.

This is one of the great services air does us. It takes up some of the heat of the sun's rays as they come through it, and keeps them from beating down on us with the terrible scorching force they would have if they came straight without passing through any air blanket. Do you remember that we found that the moon is a dead world, its surface all scorched and burned to dead dryness? That was partly because the moon has no thick air blanket to shield it. The sun's heat could get right at the surface and heat it to a scorching temperature.

The farther you are from a fire, the less heat you feel from it, because you have more air between you and the fire. So the amount of heat depends partly, at least, on the amount of air the heat has to pass through before it reaches us. Do we always have just the same thickness of air blanket between us and the sun? No, we do not, and that is why we have different climates in different parts of the world; but before we talk about the reason for climates, let us find out what climate is.

WHAT IS CLIMATE?

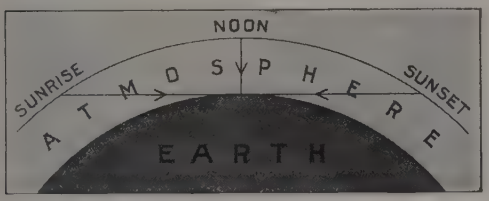
If you were a long way from home and someone asked you what kind of climate you had in the place where you lived, what sort of things would you tell him about? You would probably begin by saying that it was a very good climate, for that is the way most people feel about the climate in which they were born and brought up and to which they are accustomed. Then, if he wanted to know what made it good, you would have to tell him about the weather you had, whether it was very hot, how low the thermometer ever went, whether you had snow in winter, if there was a great deal of rain, and if it came scattered along through the whole year or all at once in one or two wet seasons with long dry times between. To tell him about your climate, then, you would have to describe the weather. But is climate weather? Yes, only it is not "one weather," not the weather of one day or one week or season, but all the weathers put together, the combination of weather changes which happen in a year and repeat themselves from year to year.

The weather in a place varies from day to day. The climate is usually much the same from year to year. This makes one big difference, so far as man is concerned, between climate and weather. A man need not travel to change his weather. He has but to stay at home and go about his daily work. As the seasons roll on, all the usual changes of weather will come, and he will have no power to help or to hinder them. But a man can change his climate. Between the equator and poles every kind of climate is to be found. One need travel but a few hundred miles up or down the globe to change one's climate radically. In a day or two of travel one can pass from intense heat to

intense cold, or from severe drought to extreme wetness.

WHAT MAKES CLIMATE?

Since the beginning of time men have puzzled about what makes different climates in different places. It was found out very early that climates run in belts across the earth. We can travel a long way from west to east or east to



PATHS OF THE SUN'S RAYS

west without changing our climate very noticeably; but go north or south a short distance, and we shall come into new weather conditions. So men made zones, or belts of climates, which were not very unlike our torrid, temperate, and polar zones. But they could not explain them fully till they knew some of the things which we know, and especially till they knew what made weather. We have seen that changes in weather are changes in the air. So we can understand that the climate of a place is really the condition of its air as to its heat or cold, moisture or dryness, healthfulness or unhealthfulness. When we can explain why the air should be as it is, we can explain climate.

THE SUN'S RAYS AND CLIMATE

The Egyptian astronomer, Ptolemy, got hold of one right idea about climate; only he did not explain it right. He thought it depended on the amount of sunlight a place received. So he made out a scheme of thirty climates running in belts across the earth from the equator to the pole, and divided them by the length of their longest midsummer day. The hottest climate had of course the longest day; the coldest, the shortest.

This was true as far as it went. Climate does depend on amount of sunlight; but amount of sunlight depends not only on the length of time during which we have the sun's rays, but also on the amount of air through which they have to travel before they reach us. This changes with different times of day and different times of year.

WHY IT IS HOTTEST IN THE MIDDLE OF THE DAY

Our air blanket is of the same depth all round the globe. If the sun stood above every point on the earth's surface all the time it would send its rays straight down by the shortest way, and would only travel the thickness of this blanket. If you want to throw a ball into a hole in the ground, and are standing right over that hole, you throw it straight down and it goes the shortest possible way. But if you are standing a little distance away, it goes slanting from your hand to the hole. It travels through more air than it did when you stood right over the hole. This is just what happens with the sun's rays. When the sun is high in the heavens at noonday, the rays come straight down and travel through the least possible amount of air; but in the early morning, and again in the late afternoon, they come slanting. The sun's rays are just as hot when they strike the top of the air blanket in the morning as at noon. But they travel through more air, so the air gets more of their heat, and we less.

WHY IT IS HOTTEST AT THE EQUATOR

Our planet, Earth, has, you will remember, two motions, one spinning round on its own axis once in each day, and the other turning round the sun in a year. The daily motion brings the sun's rays to us in such a way that it is hotter at noon than in the morning or afternoon; the yearly motion makes it hotter at the equator than at the poles. In its year-long journey, the earth keeps the middle part of the globe tipped in a more direct line with the sun than the poles. So the sun, when it shines down on the equator, shines for a longer time straight down through the air blanket, and the equator gets more heat from its rays than those parts of the earth which are usually tipped so that they get more slanting rays.

GRAND CANYON OF THE YELLOWSTONE, AND LAKE MINNEWONKA

Mountains and lakes hold water and so cool the air, making climates favorable for man. Water takes in more heat for its weight than any other substance. Hence it takes water a long time to heat or cool. That is why there is never a sudden change of temperature near a body of water. We say bodies of water modify the temperature of the air near them. This fact is made use of by fruit raisers. Many orchards and vineyards are located near the lakes or other bodies of water.

WHAT THE AIR DOES WITH THE HEAT IT TAKES UP

Ptolemy was right, however, when he thought the length of day had something to do with climate. If we depended for our warmth upon the direct heat from the sun's rays, we should be warm only when the sun shines. A cloudy day would always be very, very cold, and every night would be as cold as if there had never been any sunlight. But air helps us out again. It is probably just this way on the moon, where there is no air. An hour after sunset it is probably so cold that none of us could live there, just as an hour before sunset it would be too hot for us. But our air is really a blanket, and a good, warm one, at night. All day it has been taking up nearly half of the heat from the sun's rays as they passed through it. Now it has them all stored up, and as night falls, the earth, which has been storing up too, gives out its heat, and the air gives out even more. For the time being earth and air radiate heat; that is, give out heat rays as if they were making it, but really in the case of air it is all stored-up heat, and in the case of earth most of that which is given out in the night is what has been taken up from the sun during the day. So it makes a real difference in the heat or cold of a climate whether it has long days of sunshine and short nights for earth and air to give out heat, or short days, when air cannot have time to take up much, and long nights, when it is forced to give out every bit it has.

It is interesting, however, to think that as moon and stars keep us from absolute darkness when the sun is gone, air keeps us from complete cold during the night.

The mistake of Ptolemy and all the other early weather students was that they thought climate depended wholly on sunlight. Climate, as we have seen, is nothing more nor less than the kind of air about us. It may be not only hot or cold, but wet or dry. This is where winds and the amount of water in a place and many other things come in to make climates different. But there would be no difference in climates at all, only terribly hot days and fearfully cold nights, if it were not for the air which brings and keeps and gives out heat.

THE HEAT ZONES OF THE EARTH

SOUND MESSAGES

It is almost impossible to picture a world without sound, and yet that is what we should have if there were no air. The moon is probably an almost silent world. One of its volcanoes might crash down into one of its deep valleys, and still there would be no sound, for sound travels in waves made by particles of air. The

first thing necessary to sound would have happened. There would have been motion; only when we talk of the kind of motion needed to make sound we call it "vibration." A pendulum vibrates, that is, it swings to and fro. There is a chance for sound whenever for any reason a solid body receives a shock that sets its particles to swinging or vibrating. Have you ever been on a steamer and felt its decks tremble and quiver as the screw turned round? That is the kind of thing that happens when sound is set up.

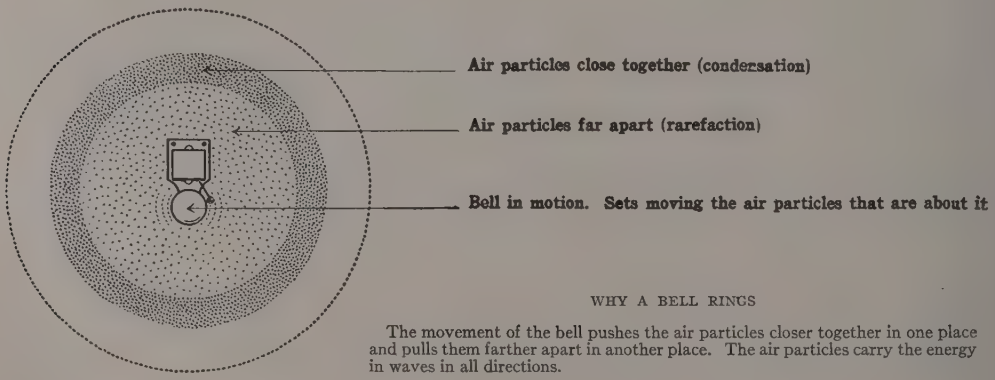
But there must be something also to take up these quivers, these vibrations, and carry them to the ear of the person who is to hear them. The air does that. It carries them along in waves like the waves of the sea until this quivering air strikes the drum of a person's ear and makes it shake back and forth with just exactly the same kind of vibration that was started by the solid which began the sound. Every sound has its own waves, which are of different length and force from those of every other sound. Then, when the waves have struck the eardrum and made it quiver, it sends the news of that motion up by delicate nerves to the brain, and the person hears.

Three things are needed, you see, to make sound, — the vibrating body, the air to carry its vibrations in waves, and the ear, made to receive them, connected with the brain of an animal or human being. Without the air there could not be sound. Could there be sound without the person or animal to hear it? That is a schoolboy's favorite puzzle. If a tree fell down in the middle of a forest where there was no animal or human being with ears which could hear, would it have made a sound? Well, would it? That is for you to decide.

HOW SOUND WAVES TRAVEL

When a wave is carried along in water or in air no single particle moves very far. The motion travels along through the air, each particle giving the one next to it a little push, and that one passing the push along to the one next it, and so on till the wave comes to some solid substance that stops it.

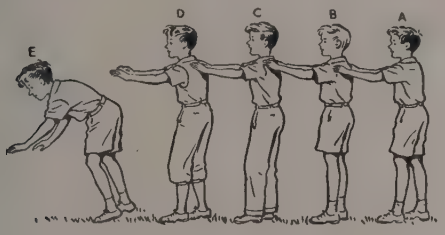
You can show this by putting a row of marbles in a groove in a board, or even in a rut in the ground. Put them so that they will touch each other. Then take another marble and drive it gently against the first one in the row. The blow given this marble by the one in your hand will be carried all down the line to the one at the other end; but if you do the experiment well and quickly, you will not be able to see any of the marbles move except the one in your hand and the one at the farther end of the line. The force of the blow given by the marble in your hand has evidently been carried down the line, for the last marble will move away from the one next to it. But you have not seen the middle ones move. They did move, but only a very little. What they did, however, was to take up the motion, each from the one behind it. But when the first marble had struck the second, it gave up its motion and came to rest. The second gave it to the third, and in


Air particles close together (condensation)
Air particles far apart (rarefaction)
Bell in motion. Sets moving the air particles that are about it

WHY A BELL RINGS

The movement of the bell pushes the air particles closer together in one place and pulls them farther apart in another place. The air particles carry the energy in waves in all directions.

its turn came to rest. Each did it so quickly that unless you were looking very carefully you did not notice it. But when the motion came to the last marble, there was nothing to pass it on to; so it moved away from the end of the line. This is just the way the air particles take a shock that makes sound. Each makes its little motion and then comes to rest, but the sound wave travels to the ear.



TYNDALL'S BOY ILLUSTRATION

BOYS SHOWING WAVE MOTION

Professor Tyndall, the great scientist, pictures a sound wave even more clearly by thinking of the air particles as if they were boys in a row, each with his hands on the shoulders of the boy in front of him. Here they are, five of them, A, B, C, D, and E. "I suddenly push A," says Professor Tyndall; "A pushes B and straightens up again himself; B pushes C; C pushes D; D pushes E; each boy, after passing along the push, becoming himself erect. E, having nobody in front, is thrown forward. Had he been standing on the edge of a precipice, he would have fallen over; had he stood in contact with a window, he would have broken the glass; had he been close to a drumhead, he would have shaken the drum. We could thus transmit (send along) a push through a row of a hundred boys, each particular boy, however, only swaying to and fro. Thus also we send sound through the air, and shake the drum of a distant ear."

WHAT THESE WAVES BRING US

It is worth while to put our minds on wave motion and learn to picture it to ourselves, for it is the way almost every message from the outer world comes to our human bodies. We become deaf and are shut out from the world of sound if our eardrums cannot receive the message which the sound waves bring to it. Blindness comes because the eye cannot receive light messages. The universe is full of messages for us, all traveling along in waves. We get just as many of them as our bodies are fitted to receive and our minds to understand and interpret.

MESSAGES FROM THE STARS

THE SWIFTEST TRAVELER IN THE WORLD

HEAT and light come to us in waves, as sound does, but fortunately they do not depend on air to bring them. Sound can travel only through gases or liquids, or through some solid body, like a telephone wire. Heat and light can journey just as well through the invisible ether which fills all space. If they could not, we should be a solitary little world, for the sun and stars would be of no use to us. The sun's light and heat must be vibrated in swift-moving waves through ninety-three million miles of ether before they get to the top of our air blanket. Light travels farther than heat. We get light from stars which are too far away to give us heat. Light is the greatest traveler in the world. While sound is a little private earth affair, tied down within a hundred miles of our planet by the air blanket, light belongs to the universe. Some of its messages have come so far that we cannot even think the distances they have traveled or the length of time it took them to come.

WHAT AIR DOES WITH LIGHT

Though light does not belong to air, yet air manages to do a good deal with it during the instant when the light wave is rushing through it. In general, as we have said, air hinders the light, slowing down its speed and softening it by clouds and dust and dampness. But in this hindering of it, all sorts of beautiful and interesting effects are produced. Air shows us light in beautiful sunset colors; it helps us to see rainbows and "northern lights"; it splits it up and reflects it and changes it in a hundred ways.

READING LIGHT MESSAGES

Messages are all very well if we can understand them; but if they are in a language we do not know or in a cipher of which we have not the key, they do not mean much. It is only within a couple of hundred years that men have had the key to light's cipher code. This is a magic key, which unlocks more doors than any Arabian Nights story-teller ever dreamed of. Hold it up in the bright sunshine or in the light of the distant stars, and it will show secret chambers which man never expected to unlock. What is this key? Only a prism, a little three-sided rod of glass, but in the hands of Sir Isaac Newton it became a scientific instrument which answered questions that had long puzzled mankind. This bit of glass is one of the greatest marvels known, for it is the key to light, and light has more secrets to tell than any other world force.

WHY THE PRISM MAKES COLORS

Did you ever play with a prism, turning it in the sunlight and watching the colored spots it will make on the wall? Twist it round and they will dart hither and thither, these little bands and bars of blue and yellow and red. Take your prism and go into a darkened room, letting a single ray of light come in through a slot in the shade. The sunlight, streaming in, will make a long, bright sunbeam in which hundreds of tiny dust particles are floating. If anyone asked you the color of the sunbeam, you would say white, or yellowish white, would you not? When the ray of light reaches the floor, it will make a spot or bar of white light.

Now take your prism and hold it in the sunbeam's path. You will have a band of rainbow colors on the floor in place of the bar of white light. Put a piece of white paper on the place where the sunlight falls, and you will get them more plainly. At first you may get only two or three colors. Turn the glass and twist it till you get them all, a perfect little set of rainbow shades — violet, indigo, blue, green, yellow, orange, and red. Do you realize what you have done? The ray of sunlight was white when it came into the room. But it is casting a rainbow of color on the floor. Think back to what we said about how light came to us by waves. You have split the white ray, which was a set of waves all coming together, into the waves of which it was made up, and these waves are giving each its color to the piece of paper on the floor.

THE MAKE-UP OF A RAY OF LIGHT

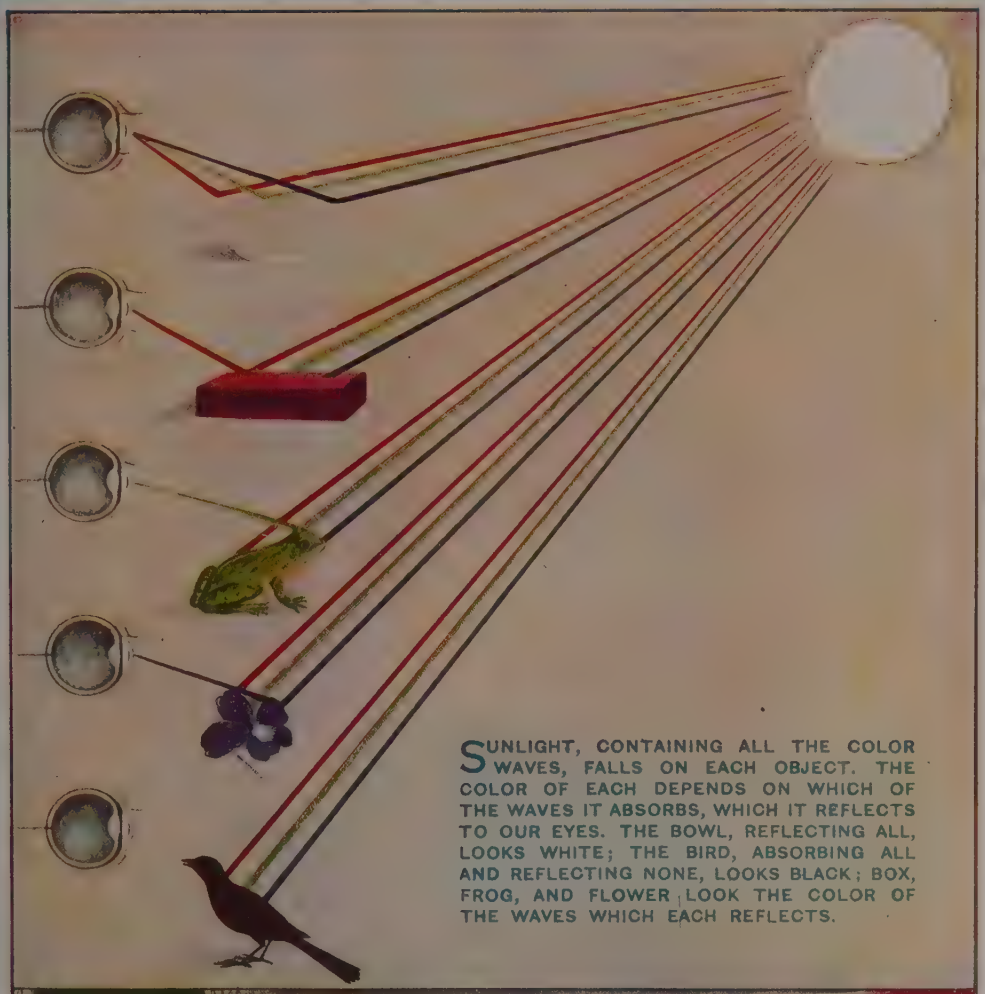
Sir Isaac Newton did this experiment with a prism two hundred and fifty years ago. He did not know, as we do, that light comes to us in waves, and so he could not give the right explanation of the colors made by the prism; but he did upset the idea which people had had up to that time that all light was naturally white. They had passed light through a piece of red glass and had said that it was dyed red by the glass. They had seen white light fall upon a green object, and had said that the object turned it green. But here was a beam of ordinary sunlight passing through a glass prism and coming out all colors of the rainbow. It was not to be supposed that the light had been colored by the glass, for the glass was colorless. The piece of paper on the floor on which it fell could not have turned it all these varied colors. Besides, they could see the colors, without any piece of paper or object for it to fall on, by looking right into the prism. Try this yourself. Instead of letting the beam of sunlight pass from the prism to the floor, kneel down and get right in its way, placing yourself so that one of your eyes is directly in line with the prism and the ray of light which is coming through it. Shut the other eye and look up into the prism. You can see all the rainbow colors coming out of the prism.

There could be no doubt that the prism somehow sorted out the various colors which made up white sunlight. But how did the prism do it? These questions waited for their right answer till the wave theory of light was proposed by Professor Thomas Young of London in 1804. Then they could be answered in a simple but very wonderful way.

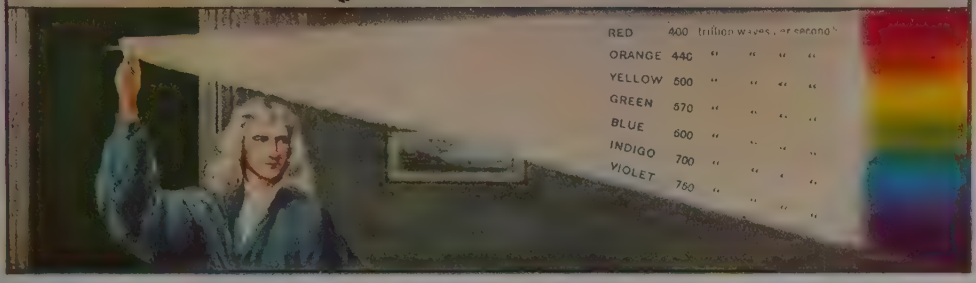
IS SPACE BETWEEN THE STARS EMPTY?

No one has seen ether. In fact, we are not sure there is such a thing. We might say it was

WHY WE SEE COLORS



SUNLIGHT, CONTAINING ALL THE COLOR WAVES, FALLS ON EACH OBJECT. THE COLOR OF EACH DEPENDS ON WHICH OF THE WAVES IT ABSORBS, WHICH IT REFLECTS TO OUR EYES. THE BOWL, REFLECTING ALL, LOOKS WHITE; THE BIRD, ABSORBING ALL AND REFLECTING NONE, LOOKS BLACK; BOX, FROG, AND FLOWER LOOK THE COLOR OF THE WAVES WHICH EACH REFLECTS.



invented to explain how light traveled. When the scientists found light was due to wave motion, they could not think of waves without having "something to wave." Since the air extended only a short distance above the earth, they knew it did not carry light, because sunlight came 93,000,000 miles, and starlight came much farther through space. They reasoned that there must be something out beyond the air. They called it "Aether," which meant "heavenly gas." We spell it "ether" to-day. It is not the ether that is given to put people to sleep.

Many scientists have been working on experiments to find whether there is really an ether. Is the space between the stars empty or is it filled with something? If we could go up there, we might find out.

Some scientists say there probably is no ether. Others say there must be. So you can take your choice. Probably before long it will be proved one way or another. However, we may still speak of light as ether waves.

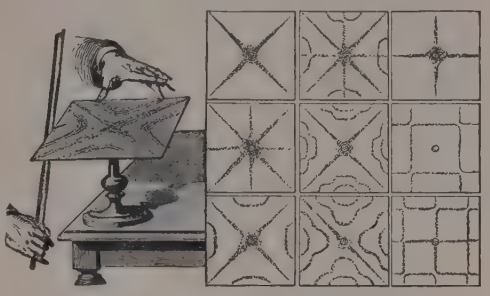
MORE ABOUT WAVES

As no one has seen or ever will see ether waves, because no one will ever be able to see the ether which fills all space but is absolutely invisible, it is plain that we must draw on our imagination to picture light waves. The nearest we can come to ether waves in anything we can actually see is in a still pond upon whose smooth surface we can make ripples.

We drop a piece of wood into the center of the pond, and we see little waves spread outwards from the center in circles, one circle following another at regular intervals. If the pond is a small one, the first wave does not take very long to reach the shore, while the others follow in a regular march; but the piece of wood still remains at the center of the pond. If we had placed corks at different points on the surface, the waves would not have carried a single cork any nearer to the shore. The corks would have merely "bobbed up and down."

Sound waves are not of this sort. They are of a to-and-fro motion, like the movement of the boys in Professor Tyndall's line, — forward, then back, and then to rest in the place where they started. This is the wave motion we see in the swaying of people back and forth in a crowd. Waves in air are of this back-and-forth kind. They are in the same direction as that in which the wave motion is traveling.

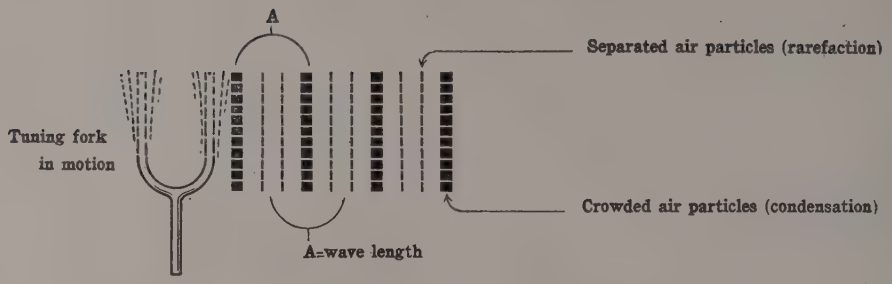
Now come back to our pond and think about the up-and-down wave, which is the only kind we have in ether. Looking at the ripples on the pond, we see that the wave motion is traveling from the center of the pond to the edge, while the vibrations of the corks, and therefore of the particles of water also, are up and down or at right angles to the direction of the wave motion. You see, we have come upon two kinds of waves, — one where the particles move backward and forward in the direction in which the wave motion is traveling, the other where they move up and down while the wave motion travels along just the same. All ether waves, and therefore all light and heat waves, are of the up-and-down kind.



BOW, GLASS, AND SAND EXPERIMENT

Sound waves can be shown by putting sand on a glass plate, and drawing a violin bow across the edge. The sand will shake into patterns like these.

Does the pond illustration make you want to ask a question? If the water waves really go up and down, why are pieces of cork and wood and seaweed constantly washed ashore by the waves? Why don't they stay out at sea bobbing up and down? They would, if the water were let alone. They do in our small, still pond. But usually water's neighbor, air, comes into the matter and drives the water with her winds and currents, until its waves go forward as well as up and down. The moon comes in, too, with her pull and makes tides; and the earth, with her pull of gravitation towards her center. So we had better go back to our ether, where the sun and stars are sending out their



HOW SOUND TRAVELS IN WAVES

The tuning-fork, when sounded, gives a push to the air particles nearest to it. The wave-like motion travels on, the diagram showing the wave length.

waves without any interference. Modern science has invented delicate instruments to measure these waves.

WAVE LENGTHS

All ether waves are of the same up-and-down kind, and they all travel with the same speed. The sun, for instance, starts vibrations, and there is nothing in ether to block them, or even slow them down, until they come to our thin little air blanket. But they do differ in the rate at which they follow one another.

Suppose instead of dropping a cork into the center of our still pond we had a float or plunger of some kind with a handle attached to it, so that we could move it up and down in the water. If we moved it up and down slowly, the waves would follow each other with considerable distance between; but if the motion of the plunger was rapid, the waves or ripples would follow close upon one another's heels. Far more waves would arrive at the shore in one minute when the plunger was moving rapidly.

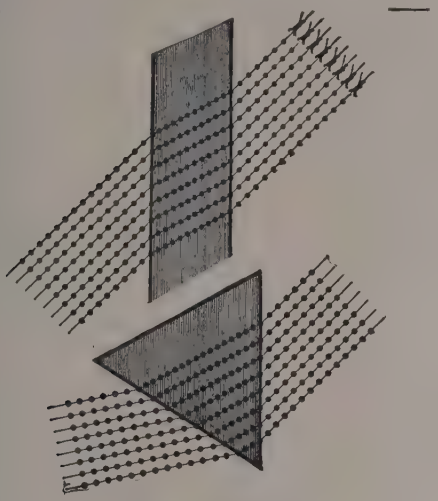
If we wanted to compare the different sets of processions of waves, we could measure the distance from the top or crest of one wave to the crest of the following wave; or we could take the distance from the trough of one wave to the trough of the next. They would be the same, as would the distance between any two corresponding points on neighboring waves. This is what we call "wave length." It has nothing to do with the length along the front or ridge of the wave. By wave length we mean the distance between two successive waves. It might perhaps better be called the width or breadth of the wave; but length is what science has named it.

LONG AND SHORT WAVES

When we moved the plunger fast we got many waves following quickly on each other, that is, waves of short length. The only difference in ether waves is in the rate at which they are made. They all travel at a speed of 186,000 miles a second after they have once been started. Later we shall see how this was found out, but the speed of ether waves is one of the facts of which we are sure.

Think of the way we give handicaps in a race. We give them because the speed of the runners is not equal. But suppose the speed was equal and we let the second runner start ten seconds later than the first, and the third after the second. Now think of the sun as the starter, sending off waves. Nobody knows how many waves it does send off in a second. But take a small number compared with what it actually does send. If it set off one thousand waves during one second, the first wave would have traveled 186,000 miles when the last wave is ready to start. In other words, there would be a thousand waves equally spread over a distance of 186,000 miles. What would be the length of each wave? We do not even need a piece of paper to calculate it. Each wave will occupy a space of 186 miles. The wave length of each of the thousand waves would be 186 miles.

All ether waves are alike except as they vary in length. Some of the ether waves used in wireless telegraphy are measured in miles;



BENDING A LIGHT BEAM

In the upper section a ray of light is going through a pane of glass; in the lower through a prism.

others are so extremely short that they can only be measured in fractions of an Angstrom unit — and one Angstrom unit is only 0.003937 millionths of an inch.

When long waves — that is to say, far-apart waves — are sent out in the ether we have radio waves by which we send our wireless messages. Shorter waves are set up and we have heat; shorter waves still, and we have light; still shorter, ultra-violet light; then X-rays, and so on. All of them are ether waves, but some affect our eyes, some make our bodies feel warm; some, like the waves which carry wireless messages, make no impression on our bodies, but do on delicate instruments which man has been able within twenty-five years to construct.

WHAT IS LIGHT?

Now we can come back to our prism and understand why it can sort out the colors from a ray of white light. Light we have found to be simply a stream of ether waves of various lengths. When they fall on our eyes they make different sensations take place. If they all enter the eye at once, all "in a bundle," so to speak, they make a certain sensation which we call "white." It is as if a bullet flying through the air struck a soldier and caused a sensation of pain in him. The bullet and the pain are totally different things. Light is not really white or colored. The ether waves, flying through the air, strike the eye and make a sensation. When they strike all together, the sensation is white; when they are separated, we see colors, and different colors according to the lengths of the different waves.

BENDING LIGHT

First of all we must notice what happens when ether waves fall upon any piece of ordinary glass like a windowpane. If a beam of sunlight came straight at a glass pane, or, in other words, if it struck the glass at right angles to its surface, the waves would go straight through and keep on in a straight line. This happens when a ray of sunlight strikes a skylight in the roof and travels to the floor below the skylight. But picture the beam of light striking the glass at an angle and see what happens, remembering always that glass hinders the light waves, because it is harder to go through than air, even as air is harder to go through than invisible ether.

A SOLDIER ILLUSTRATION

The best way to picture a light wave striking glass is to imagine a line of soldiers as representing the wave front. Think of them as marching well in line and approaching a stretch of rough country (the piece of glass). Remember that they are not going straight at it, but are coming in a slanting direction, so that the soldier on the extreme right will enter the rough country first. He will not be stopped; the pane of glass will let the wave through. But his walk will be hindered, and his pace across the rough country will be only two miles an hour as against three miles in open country. As each soldier enters the rough section his speed is cut down, but

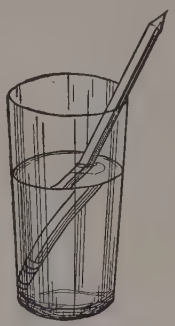
the soldiers on the extreme left of the line will have marched in the open country longer than the others. Therefore they will have kept up their full marching speed of three miles an hour longer than those who first entered the rough piece. These right-hand soldiers will have slowed down so much by this time that the direction of the line of march (that is, of our light-wave front) will be considerably altered.

Once in the rough country they all march again in even line, but they are still marching in a slanting direction, though not at quite such a sharp angle as before. Those on the extreme right, who entered the rough country first, will be out again first, so that they will get ahead of those who were later in leaving the open country for the rough. What takes place now is exactly the opposite of what took place when they were entering the rough country. Those on the extreme right will make up their lost lead while those on the extreme left are being delayed by the rough country, and on the other side of the rough piece the line of march will swing round into the same general direction that it had way back on the open smooth ground.

While we have been going through this long story, millions of ether waves, starting from the sun, have been striking your windowpane at an angle, pushing their way through the glass, coming out again at the same angle at which they entered, and traveling across your room in slanting rays of sunlight. You did not see them bent in the glass, because the glass was so thin and they went through so fast; but it happened every time, as you will be able to prove for yourselves some day in a physics laboratory, where you can see lenses bend light. You can try an experiment now.

HOW WATER BENDS LIGHT

This bending of light is called "refraction," from the Latin words, "to break back." Take a stick and put it in water, and you will see where this light-bending got its name. Light always comes to us in straight lines. It cannot turn corners or go in curves. That is why it casts shadows. If you come between the light and the wall, the light is stopped in its journey by your form, and the outline of your form stands out dark upon the wall. But when it enters a new substance, like water or glass, it is bent (refracted) in another line. The second line is straight, too; but it is not the same line as the first one. Have you found out what the light on the water has been doing to your stick? Try it with a pencil in a shallow basin full of water. Your stick does not look straight any longer. It looks as if it had a joint in it where it struck the liquid. But it is still straight, is it not? Yes, but it looks bent because the water bends the light rays and sends them to your eye from another direction.



PENCIL SEEMS TO BE BENT BY LIGHT

REFLECTING LIGHT

When light strikes something which it can travel through, we call that body transparent. It may refract the light, but it will let it go through and come out on the other side. Most things, however, do not let light pass through them. The ether waves strike the surface and are *reflected*, that is, turned back. A mirror reflects your image back to your eyes. The sunlight falls on the ground and is reflected up to our eyes, else we should not see the ground. The moon floating in the sky reflects the sunlight to us, else we should never know there was a moon. Only a few things shine by their own light. They are what we call "light-giving bodies," such as the sun, the stars, electric lights, lamps, candles. They give us light directly. Everything else reflects sunlight. When it is dark, when the sunlight is shut off and there is no light in its place, not only do we have no light, we do not even see the things about us. Unless we run into them, or hear them, or smell them, we should never know they were there.

WHAT MAKES COLOR?

Different wave lengths make different colors. When you bent the ray of sunlight by the prism, you separated these waves so that they showed their colors. Going through a windowpane,

the marching army of your wave front had a chance to get together again in the same direction and come upon your sight all at once as white light. But your prism was three-cornered and three-sided as well as transparent. It was as though your line of march entered not a straight patch of country with its two boundary lines parallel to each other, but a triangular one, where some soldiers would cross only a little corner and others go through the middle. Besides, when we consider light waves instead of marching soldiers, we must keep in mind that some are bent more than others by glass; that is, some find it harder to march through. The shorter the wave, the more it will be bent. Your prism takes the rays of light as they strike its surface and bends them in carrying them through itself, sending them off at different angles, so that they do not come out all at once. They are also split up by being turned, and they can't get back together because they must travel in straight lines. So we have on the floor the mark that each ray would make if it could come alone. Turn back to the diagram on page 105 and compare the line of march through the pane of glass and the prism. You will get a clear idea of the effect of the latter on the ray of light.

THE SOLAR SPECTRUM

The band of colors given out by the prism is the band of sunlight colors which our eyes

SPECTRUM OF THE SUN AND OF THE STAR CAPELLA

Each star has a spectrum of its own. Capella's is very like that of the sun.

can see. It is called the "solar spectrum," or sun image. The colors are always in the same order. Violet rays are shortest; so they come at one end; red rays are longest, and between come indigo, blue, green, yellow, and orange. But when we talk about length or shortness, let us stop to find out what sort of lengths we are really talking about. The wave length of red may be longest, but it takes thirty-four thousand red waves to cover an inch. Violet rays are so short that it takes sixty-four thousand waves to make an inch. These are the tiny waves beating incessantly on earth which make what we call "color."

Another way to get some idea of the rate at which the sun sends them out is to calculate how many of them pass any point in a second. It has been worked out that of waves producing the sensation of red, about four hundred trillion would get by in a second; of orange, four hundred and forty; yellow, five hundred; green, five hundred and seventy; blue, six hundred; indigo, seven hundred; and violet, seven hundred and fifty trillion.

WHY DO THINGS HAVE DIFFERENT COLORS?

The prism was transparent. It took up all the waves of light which struck it, carried them through, and sent them out again, to give all seven colors and their shades between them in a perfect spectrum on the floor. But most objects are not so obliging. They take up some of the light waves and keep them; others they reflect back to our eyes, and we say the object has the color of those waves. It is easy to believe that everything is without color in the dark when no light is falling on it. But it is harder to believe that the color of a body is due to the light waves which it takes up or does not take up. But this is true. A piece of red cloth is red because when white light falls on it all the colors of the spectrum but red are absorbed or turned into heat, the red waves only being reflected to our eye. The color of an object comes from something in itself which makes it take up certain light waves and reflect certain others.

WHY DO THINGS CHANGE COLOR?

Did you ever buy a pink ribbon and find that it looked yellow at night under artificial light? Or have you ever seen your mother take a piece of goods to the door of a shop to find out what color it was? If so, you will be more ready to believe that the same thing will not have always the same color. In sunlight it will look what we call its "real color," its daylight

color. But artificial light will not have so many wave lengths as daylight, and the ribbon or cloth will look a different shade simply because some of the daylight wave lengths were not there to be reflected to your eye.

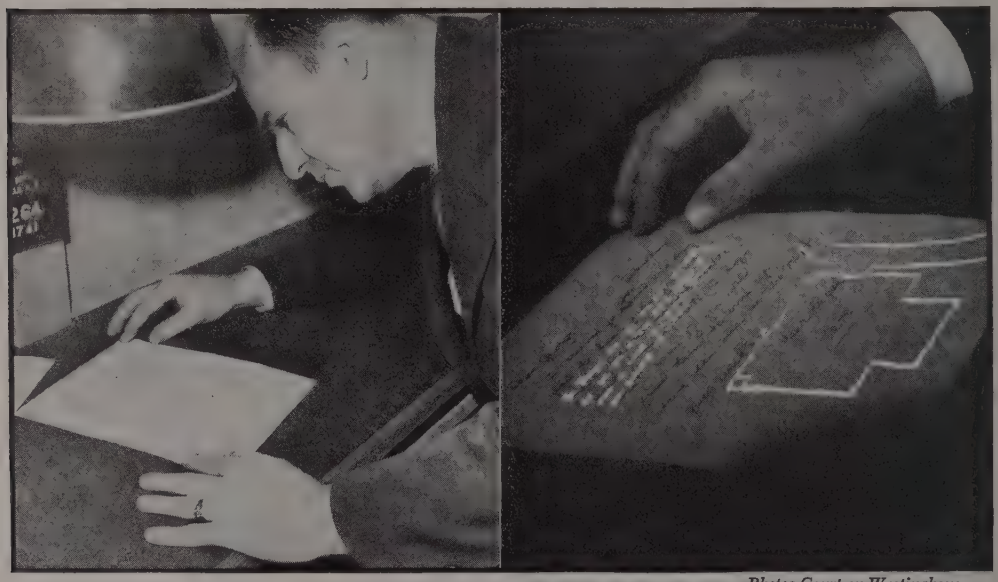
ULTRAVIOLET WAVES

Ultraviolet waves, which we can neither see nor feel, are even shorter than the shortest (violet) visible light waves. They are sometimes called "black light." These waves are valuable to our health for they have the power to kill some forms of bacteria and also to create Vitamin D. The special sun-lamps used by doctors and also in our homes give off ultraviolet waves as well as visible light. The ultraviolet waves cause rapid tanning of the skin which some people desire; but their real value is in helping to build up Vitamin D within the body. They are also used to create greater quantities of Vitamin D in some foods. Irradiated milk is an example of this. (See Volume Two, page 301.)

An interesting fact is that numerous chemicals and organic substances will "fluoresce," or shine in the dark, when exposed to "black light." This fact has been used by magicians to create many weird effects. It has also been used by spies to send secret messages. A message written in certain chemicals, or even in lemon or onion juice, across the face of an innocent-seeming letter will not show in ordinary light but will shine out brightly when the letter is placed under ultraviolet light.

INFRARED WAVES

Longer than the longest (red) waves of visible light but shorter than radio waves are the infrared waves. These we cannot see but do feel as radiant heat. It is the infrared waves from the sun that heat the earth. Were it not for this heat from the sun, our world would soon grow so intensely cold that no living things could continue to exist. The heat-giving power of the sun is well shown by the fact that a "burning-glass" or even a curved bit of glass from a broken bottle can concentrate enough of the sun's rays at one spot to start a fire. One should never drop broken bottles or glass of any kind in an exposed place in the woods,



Photos Courtesy Westinghouse

A DETECTIVE BRINGING OUT A SECRET MESSAGE AND MAP BY MEANS OF ULTRAVIOLET LIGHT

THE SUN SPECTRUM AS SEEN IN NATURE

lest it start a fire in this way. There are even sun motors, run by the sunlight, turned into heat, and then into energy.

It is an interesting fact that heat and light rays seem to meet the same response in certain cases. In hot countries people wear white, and both "look cool" and "are cool." White throws back all the rays of light and heat that it can. Black takes them all up. Take two pieces of cotton cloth of exactly the same quality, one white and the other black, and put them on a snowbank where the sun is shining. The snow under the black cloth will melt long before that under the white; the black cloth has absorbed the heat waves and passed them on to the snow, while the white cloth has reflected them (turned them back) and thus protected the snow. Kinds of cloth make even more difference with heat than colors, but even colors have a real effect.

WHY THE SKY IS BLUE

We go "all round Robin Hood's barn," as the old saying has it, studying out facts and laws which seem very far away from our everyday life, and then all of a sudden they have brought us back to some simple happening which is so familiar that we have never thought to ask the reason for it. We study wave lengths of light, and find out why a piece of cloth is red. We learn about our air blanket with its water vapor and dust floating in it, and all at once we can tell why we look up into blue sky.

In the first place we know now that when we see any color at all except black we are seeing light, because it is only through light waves that our eyes get the sensation of color. So the color we see in the sky is really light. Now this light comes from all over the sky, doesn't it? It is brightest in the direction where the sun is but it comes from other directions too. If that weren't so we would never get any light through our north windows for instance. Why does this light come from all over the sky instead of just the one spot where the sun is? It is because it is "diffused" when passing through the earth's atmosphere. Diffused simply means scattered, and that is exactly what happens to the sun's light as it travels through the atmosphere. The light is reflected and refracted in all directions by the billions of tiny particles of water vapor in the air, by the billions of dust particles, even by the molecules of oxygen and nitrogen which make up the air.

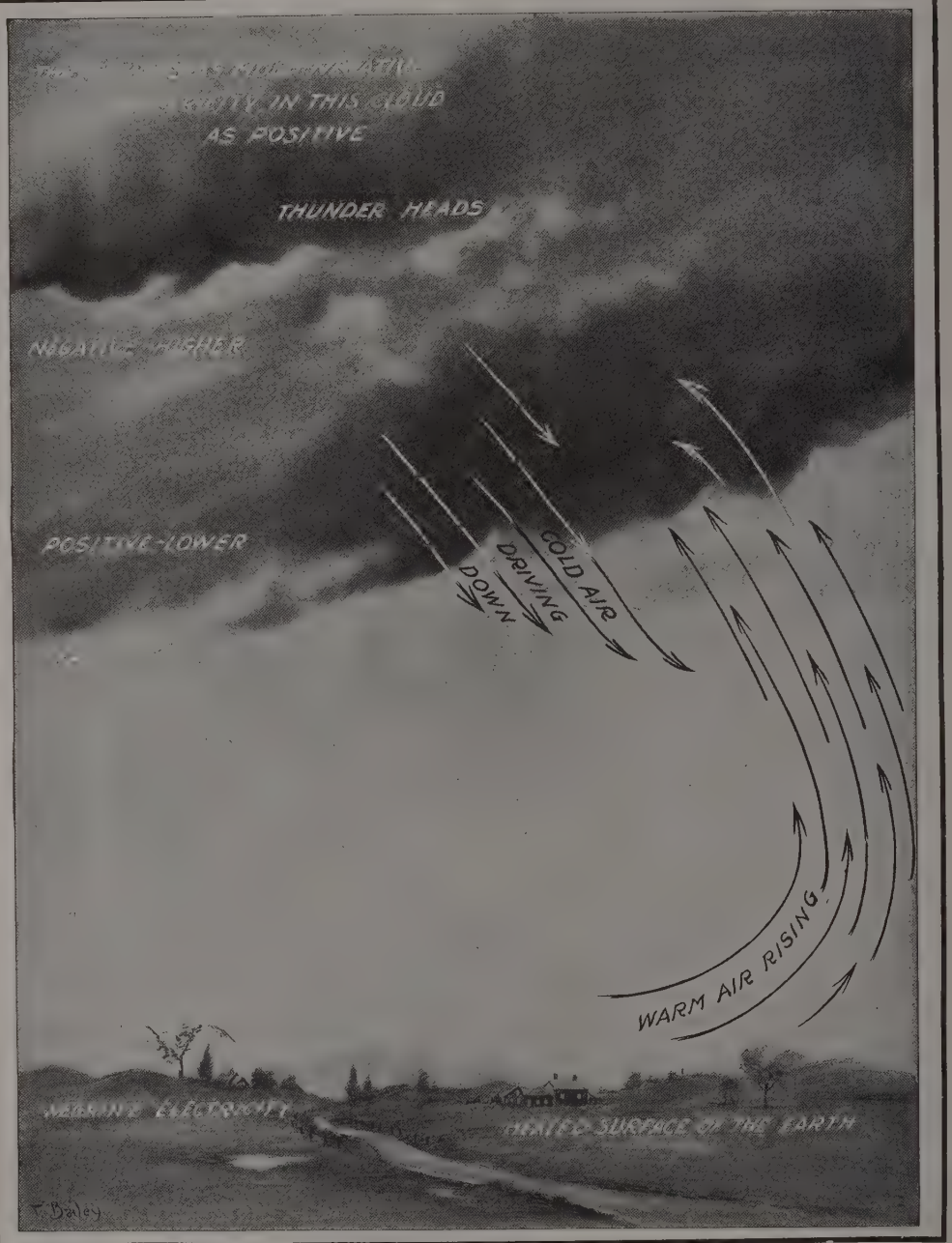
This scattering or diffusion is greatest for the shortest wave lengths of light. Accordingly, violet light is the most diffused but it is scattered so very much that little of it penetrates to the earth's surface. Blue is the next shortest wave length and in clear atmosphere it is scattered just enough to come to our eyes from all parts of the sky. This, then, is why the sky usually looks blue. On days when the air contains unusual amounts of diffusing particles (dust, water vapor, etc.) the longer wave lengths are more diffused and the sky may look green, yellow or even red. You may have noticed these colors in the sky during or after a dust storm. Of course, at no time do we get light from the sky that is entirely of one wave length. There is always some light of every wave length present. The color we see in the sky is determined by the wave length that is dominant, that is, the one which is present in the greatest quantity.

Sunset colors are usually the longer wave lengths, reds, yellows and sometimes greens. At that time of day the sun's rays come slanting to the earth and travel a longer distance through the atmosphere (See diagram on page 97) and only the rays which are least diffused are able to get through to the earth.

CLOUD COLORS

When the sky is covered with a rather thick layer of cloud it becomes gray. This is because the water droplets are large enough to reflect and refract all wave lengths of light and what little light gets through to the earth is white light which as we have seen is made up of all colors or wave lengths. Gray light is simply weak white light, and as the clouds get thicker the gray of the sky becomes darker and darker until with heavy rain or storm clouds the sky is almost black. Light, fleecy clouds floating in an otherwise clear sky look white because the strong white light of the sun which brings their image to our eyes is reflected and refracted

WHAT HAPPENS IN A THUNDERSTORM



HOW THUNDER AND LIGHTNING COME

The surface of the earth and the air immediately above it become warmer than the upper air. The warm moist air rises, clouds gather, cold air begins to drive down. Rain falls. Clouds and air currents acting on each other build up electric charges, positive in the lower part of the cloud, negative in the higher. When these charges become great enough lightning flashes occur within the cloud and between the cloud and the earth. Thunder is the "explosion" of suddenly heated air along the lightning's path.

at their surface instead of having to filter all the way through them.

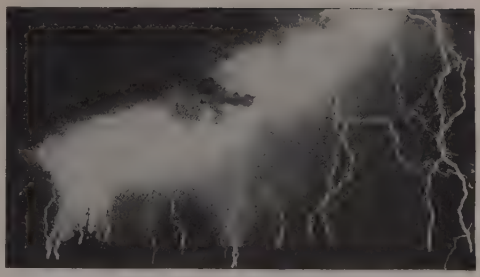
THE RAINBOW

A rainbow may be seen when rain is falling somewhere in the distance and the sun is shining on the same side of the rainfall that you are on. This is nature's own sun spectrum. Instead of the glass prism, however, millions of tiny raindrops are reflecting and refracting the sun's rays to make a wonderful arch of colors across the sky. At Niagara Falls or at any great waterfall beautiful rainbows can be seen in the spray when the sun is in the right position. Try making your own rainbow some sunny day by sending up a high spray of water from a lawn sprinkler. Be sure that you and the sun are both on the same side of the spray.

THE AURORA BOREALIS

More mysterious and less frequent than the rainbow or the sunset colors is the appearance in the northern sky of the beautiful colored bands or streamers of light reaching far into the heavens, known as the "aurora borealis" or the "northern lights." These are seen to the best advantage in the polar regions, but are sometimes visible also in the more inhabited regions of the earth. An aurora which occurs in the Antartic region is called an "aurora australis."

About all that can be said with certainty about this beautiful and mysterious spectacle is that it is an electrical display occurring in the rarefied upper atmosphere sixty miles or more above the earth. It is not definitely known how these displays are caused but at least they are influenced by the condition of the sun, since they are apt to be most numerous and most extensive when there are large spots on the sun. The most commonly accepted theory of their origin is that streams of electrons from the sun are attracted by the earth's magnetism to the north and south magnetic poles where they in some way cause the upper atmosphere to glow. It is true that the auroral displays seem to center around the magnetic poles. Most auroras are white, but at times they may be green, yellow or red.



LIGHTNING, SHOWN BY AN INSTANTANEOUS PHOTOGRAPH

THUNDER AND LIGHTNING

Benjamin Franklin with his kite was the first to draw electricity from a thundercloud and so to prove that the lightning flash and the thunderclap were both caused by electric discharges in the atmosphere.

There are many kinds of thunderstorms and lightning flashes. Lightning is a discharge, or unloading, of electricity from one cloud to another, or one part of a cloud to another part, or from a cloud to the ground. The thunder is the sound produced by the sudden, intense heating and consequent expansion and disruption of the air along the path of the lightning flash. It is really an explosion sound. The rumbling is caused by the differences in distance from the listener to the various parts of the lightning's long and crooked path. The sound from the nearer portions naturally arrive first. Sometimes lightning flashes occur in such rapid succession that the sounds overlap, making a long continuous rumble and roar.

LIGHT TRAVELS FASTER THAN SOUND

It was Jupiter's moons that taught scientists the exact rate at which light always traveled. Galileo found four moons with his telescope. Then all the astronomers studied them and discovered to their surprise and distress that they did not keep time. As the four little moons traveled round Jupiter in the orbits which the astronomers had worked out, they would disappear into the shadow of the planet a quarter of an hour sooner than was expected, or they would lag along a few minutes late. But how could this be possible?

An astronomer named Roemer worked on the puzzle for a long time, and at last, in 1675, he solved it. The moons kept time, but it took them a certain length of time to get their message of light to earth. Jupiter was not always the same distance from us. In the great orbit through which he traveled, he was at one time on the same side of the sun as the earth, and only 394,000,000 miles away; but six months later he was on the other side of the sun, and 580,000,000 miles away. This made a difference of 186,000,000 miles, and a delay in the arrival of light from the moons.

Roemer knew how far away Jupiter was, and made his reckoning. When Jupiter was farthest away, it took his light sixteen and one-half minutes more. By simple division he could find that the light traveled at a rate of 186,000 miles a second.

While light goes 186,000 miles, sound goes only 1100 feet. This explains why you can see lightning before you hear thunder. Also, why you can see the smoke come from a gun, shot at a distance, before you hear the shot. Did you ever see or watch a train whistle for a crossing at a great distance? Did you hear it whistle or see the steam come from the pipes first?

FORCES WHICH PLAY ABOUT EARTH

Heat, light, sound, electricity, and magnetism — these are some of the forces that play about the earth on which we live. Of the last two we have said hardly anything. They act in the air and in the earth's crust. Their story will come in the story of inventions, for its interest is in the way man has used them. All these forces belong in the earth story because they act constantly upon the earth, making it warm and bright, and giving it the power to keep up life. If it were not for these forces there would be no human beings on earth.

These forces have always been present in the universe. When man learned to build fires, he was starting to use heat. When he talked, he used sound. Now he has learned many new ways of using all of these forces. They, in turn, are making things easier for him. From the time we get up in the morning until we go to bed, we are calling upon these forces which have become our servants.

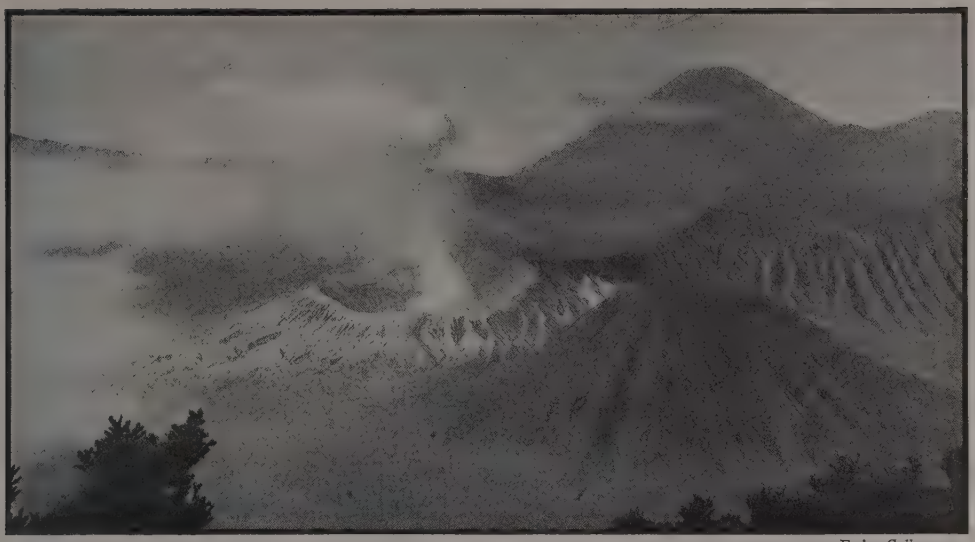
Man has done much more than receive these forces and live in their presence. He has set them to work for him. He has applied heat to the boilers of steam engines and thus obtained power to drive his trains, ships and factory machinery. He has used light to make photographs and moving pictures and has even detected the existence of invisible light rays such as the infra-red, ultra-violet and x-rays and has turned them to useful account. He has learned how to record and later reproduce sound through the phonograph and dictaphone and, with the aid of electricity, to transmit sound hundreds and even thousands of miles by telephone or radio. He has used the earth's magnetism to swing the compass needle always north and so guide him in his ocean voyages and explorations. He has turned electricity to a myriad uses in the fields of light, heat, power and chemistry.

Every day man finds some new way to make these willing forces his servants, and the story of how he has done this is the story of his inventions. *Invention* comes from the Latin verb, "to come upon" or "find out," and means nothing in the world but what has been found out. When you have read the story of inventions in Volume Two you will see that, wonderful as earth with all its forces is, man who can master it with his mind and make it do his bidding is more wonderful still.

Photos by courtesy of W. A. Russell, Esq.

THE VOLCANIC BIRTH OF A NEW ISLAND

Anak Krakatoa ("Child of Krakatoa") as it rose from the sea off Sumatra in 1929, on the site of the island volcano, Krakatoa, which blew up in 1883 (see p. 118). At the top left, it is throwing steam and black cinders to a height of 1000 feet; at the top right, the island volcano throwing up clouds of steam. At the bottom left, the sea pouring into the crater; at the bottom right, a near-by island, one of several created by the great eruption of Krakatoa in 1883.



Ewing Galloway

A GROUP OF VOLCANOES IN JAVA

THE EARTH A WONDERBOOK

THE EARTH'S MIGHTY FORCES

THE earth is as much a wonderbook to us as it was to the ancients, though in a different way. They sought to account for it by stories, strange tales of gods who stirred in their sleep and caused earthquakes, or breathed forth mighty blasts of flame and made volcanoes. These stories were the ways they had of expressing their sense of awe and of powerlessness before the mighty forces of Nature.

We think we understand the earth better. Men have learned in thirty or forty centuries many of Nature's laws. But the wonder is never taken away; rather it is deepened. The more we know of the tremendous forces at work inside and outside our earth, and of the marvelous balance in which they all work together, the more we are filled with awe and admiration. To say that a volcano must have a god under it, else how could it send out fire, was to confess that it was a miracle, something beyond human understanding or explanation. But to those who study the earth and attempt to learn what it has to tell of its own history, it is of the greatest interest to search for the real forces at work in the production of volcanic action.

Let us come to this earth book in the spirit of the myth makers, seeing the marvelous things all about us and trying to explain them, and in the spirit also of the true scientist who, after he has searched as far as he can into its mysteries, still pauses in reverence and admiration before the mighty universe of which he is so small a part. In these stories we shall meet the results of the action of tremendous earth forces, as they have operated in the long-distant past and as they are working to-day. We shall read of mountains, rivers, and deserts, of volcanoes, floods, and earthquakes. So the earth was made, and so it is now in the making.

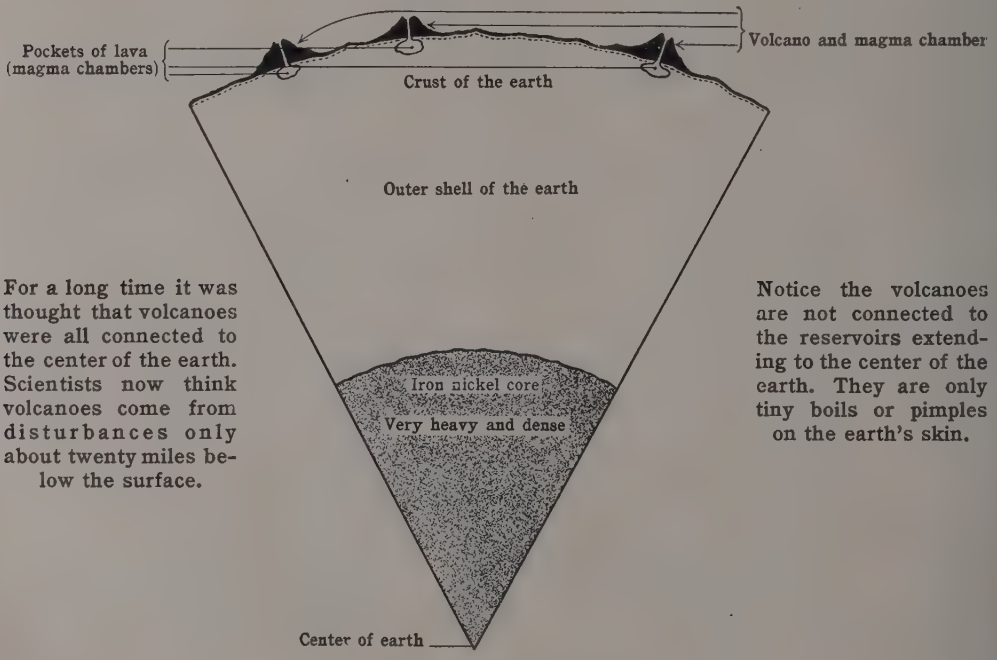
VOLCANOES

WITHIN the borders of the United States we have at present very little experience of active volcanoes. There is, to be sure, a "fire belt" stretching around the Pacific, extending from Tierra del Fuego, or the "Land of Fire," the group of islands at the extreme end of South America, up along the Pacific coast and Alaska to the Arctic circle, and down through Japan and the East Indies.

But of the volcanoes in our country, Shasta, Hood, Rainier, and Baker, of the Cascade and Coast ranges, are either dead or faintly active. Mount Lassen, in the Sierra Nevada mountains of California, shows occasional puffs of smoke above its summit. The water contains a seething mass of hot material. In winter, when the mountain is covered with snow, the warmth of the crater is great enough at times to keep the snow melted from the tip of the cone.

The Greeks and Romans lived in one of the great fire belts of the world, the belt that encircles the entire globe. It is from the Greeks and Romans that we get our name "volcano."

Etna and Vesuvius were their most active volcanoes, of which they had frequent and fearful reminders. It is little wonder that the gods of fire were to them among the most terrible and yet most familiar of their deities. One legend told of the mighty Typhœus, hundred-headed giant with flashing eyes, whom Zeus had conquered with a thunderbolt and buried under Mount Etna. The most famous story made Etna the home of Hephæstus, god of all fire. Hephæstus was lame, but very strong and powerful. He was kept always busy in his mountain workshop, toiling at his forge, with the one-eyed Cyclopes for forge men, making thunderbolts for Zeus, the ruler of heaven. Later on the Romans took Hephæstus for their own and named him Vulcan. *Vu*lcan-o has become *vo*lcano in English. So every time we speak of a volcano we are going back to the old fire-god legend of three thousand years ago.


Pockets of lava (magma chambers)
Volcano and magma chamber
Crust of the earth
Outer shell of the earth
Iron nickel core
Very heavy and dense
Center of earth

For a long time it was thought that volcanoes were all connected to the center of the earth. Scientists now think volcanoes come from disturbances only about twenty miles below the surface.

Notice the volcanoes are not connected to the reservoirs extending to the center of the earth. They are only tiny boils or pimples on the earth's skin.

A SECTION OF THE EARTH FROM CRUST TO CENTER

Keystone

WHEN MOUNT MAYON IS QUIET

This volcano of the Philippines is noted for its perfect cone.

WHAT IS A VOLCANO?

What is a volcano? A burning mountain, you say; a mountain or hill, usually more or less cone-shaped in form, from which lava, cinders, steam, sulphur gases, and the like are thrown out, says the dictionary. For a long time it was thought that the inside of the earth was filled with fire. People knew it grew warmer the farther down they went beneath the surface. Any one who has been in a mine knows that it gets warmer as one goes down. Then, too, they saw hot melted rock and ashes pour out as if from the top of a furnace. Hot springs also seem to show that it must be very warm beneath the surface of the earth.

The inside of the earth is very hot because of the many layers of rock that press down on it. The scientists have been trying to find out whether the inside of the earth is liquid or solid. The ancient people thought it was liquid because they saw liquid pour out of the volcanoes. Even until recently the solid part of the earth was supposed to be only seven miles deep. The part we live on was thought to be only a crust. The crust was just a little part that had cooled.

Scientists have measured the earth in many ways. They have studied the jar that comes from earthquakes which travel through the interior of the earth. From this study they know now that the interior is very heavy or dense.

Even though it may be liquid, it is solid enough to hold up the outside of the earth.

The volcanoes come from little chambers of liquid rock which are not over 20 or 30 miles deep. Thirty miles is not deep as compared to the 4000 miles from the surface to the center of the earth. The volcanoes come from little pockets near the edge of the water.

We do not know what causes the pockets. It is probable that materials which melt easily have happened to get together in the magma chamber (see diagram) beneath the volcano. Then, too, it is possible that some substance like radium may have gotten into these pockets.

The new idea of volcanoes makes us feel much safer than did the older one. As long as people thought they lived on a thin crust which had cooled on the top of a globe of red-hot lava, they worried for fear the crust might crack. Now, we know the earth is quite solid.

THE MOUTH OF THE VOLCANO

As you come near a volcano, or climb to its top, you will find that it is as if the point of the cone were cut off. Other mountains end in peaks or ridges or mounds. At the top of the volcano there is a depression, a great hollow, like an empty bowl. The name for this hollow comes from the Latin word for bowl, *crater*, which in its turn comes from Greek and Sanscrit words, to mix or to cook. This is the crater of the volcano, and a great mixing bowl it is, if the volcano is alive and in full action. It is the mouth of the volcanic channel, through which its burning contents are poured out. Let us take a look, through the eyes of a famous geologist, Mr. Whymper, into the crater of Cotopaxi, in South America.

"An amphitheater 2300 feet in diameter from north to south, and 1650 feet from east to west, with a rugged and irregular crust, notched and cracked; surrounded by cliffs, by perpendicular, and even overhanging, precipices, mixed with steep slopes — some bearing snow, and others apparently encrusted with sulphur! Cavernous recesses belched forth smoke; the sides of cracks and chasms, no more than halfway down, shone with ruddy light; and so it continued on all sides right down to the bottom, precipice alternating with slope, and the fiery fissures becoming more numerous as the bottom was approached. At the bottom, probably 1200 feet below us, and towards the center, there was a rudely circular spot, about one-tenth of the diameter of the crater, the pipe of the volcano, its channel of communication with lower regions, filled with incandescent if not molten lava, glowing and burning; with flames traveling to and fro over its surface, and scintillations scattering as from a wood fire; lighted by tongues of flickering flame, which issued from the cracks in the surrounding slopes. At intervals of about half an hour the volcano regularly blew off steam. It rose in jets with great violence from the bottom of the crater, and boiled over the lip, continually enveloping us. The noise on these occasions resembled that which we hear when a large ocean steamer is blowing off steam."

THE ERUPTION OF VESUVIUS

Volcanoes are dangerous in that they may appear dead for a long period and then flame into fearful activity. The eruption of Vesuvius in 79 A. D. was of this character. Up to that time the people living in that region were not aware that Vesuvius held any danger for them. Unafraid, they built their homes and tilled their fine farms and vineyards over the quiet sides of the slumbering volcano, then called Monte Somma. In fact, they did not believe that the mountain was a volcano. Even repeated earthquake rumblings, which took place as early as the year 63, did not disturb their confidence in Monte Somma. Then, one August noon, a huge black cloud rose from the crater of Vesuvius, and filled the air with dust and ashes. Blocks of stone fell all over the country round. The sea was lashed to fury. For almost two days the eruption lasted, and covered the country within a radius of fifteen miles with white ashes that looked like deep snow. Three cities, Herculaneum, Pompeii, and Stabiæ, were buried under a flood of volcanic mud and cinders. One man, who is called the Younger Pliny, saw the catastrophe from a safe distance, and described it in letters that we may read to-day.

In our day men have dug out Pompeii and Herculaneum, finding that these buried cities can show us very plainly what kind of houses

INTERIOR OF VESUVIUS, FROM A PHOTOGRAPH TAKEN JUST AFTER A VIOLENT ERUPTION, SHOWING HOT LAVA AND CLOUDS OF STEAM

International News Photo

VESUVIUS IN ERUPTION IN 1944

people had and how they lived in the first century.

This eruption of Vesuvius also did large damage to the volcano itself. Half the crater wall was blown to pieces. The present cone is a new one within the old crater.

Vesuvius has repeatedly shown itself an enemy to mankind. Again and again it has covered the neighboring regions with deep blankets of ashes and lava. In 1631 there was a fierce outbreak, ruining several towns and taking toll of about 18,000 lives. In the eruption of 1906 the cloud of ashes above the summit reached a height of 17,000 feet.

For a long time this volcano has been in a state of perpetual excitement on a small scale, and an observatory has been built near the top for the study of these disturbances. Scientists live at this observatory. They study Vesuvius. They have been able to warn the Italian people of an eruption just as our Weather Bureau tells us of a coming storm or flood. Receiving a warning, the people can move to some other place until after the eruption is all over.

MONT PELÉE

On May 8, 1902, the outbursts of Vesuvius were equaled by Mont Pelée in Martinique, when the beautiful city of St. Pierre was blotted out. The destruction was caused not by lava, but by a tremendous cloud of hot gases, permeated with white-hot particles of rock. This great mass rolled downwards toward the sea, traveling at times nearly a mile a minute. Between 25,000 and 30,000 persons were killed in the space of several seconds. At this time Mont Pelée added about 2000 feet to its height.

THE BLOWING UP OF KRAKATOA

The blowing up, in 1883, of the small volcanic island Krakatoa, in the Pacific, near Java, came after two centuries of quiet, and remains the most appalling eruption recorded in modern times. Half the island was blown away, and the noise of the explosion was heard for hundreds of miles. Volcanic dust fell at great distances, and some of the finest particles remained in the air for months, producing strikingly beautiful sunset effects in various quarters of the world. The Krakatoa eruption created a giant ocean wave that reached a height of 100 feet. It swept over near-by land, and drowned 35,000 natives.

AN ERUPTION IN OUR OWN POSSESSIONS

On January 30, 1911, the Taäl volcano in the Philippines erupted with terrible violence, laid waste 142 square miles of surrounding country, and killed 1400 people. Following is the account of William Couch, an engineer in the United States Army:

"With a mapping and surveying party I was camped at Bayuyungan, Batangas, on January 28, 1911, when the Taäl volcano went into a state of eruption. The camp was located about four miles northwest of the crater, and about a quarter of a mile from the shore of Lake Taäl. About 3 A. M., January 28, the volcano showed signs of eruption. There were severe reports caused by the explosion of gases above the crater, and an electrical display lighted up the heavens. Large volumes of smoke were pouring out of the crater, and were carried off to the southward by the wind. This condition lasted about three minutes. Earthquakes of more or less severity were felt throughout the dawn of January 28. Smoke issued from the crater and ashes fell in our camp all this day and the next. About 1 A. M., January 30, I was awakened by a loud rumbling noise. I got up and stepped outside of the tent. Looking across the lake in the vicinity of the volcano, I saw great volumes of black smoke pouring out of the crater, accompanied by heavy explosions, resembling heavy artillery in action, and electrical display. The smoke drifted over our camp, and there was a light fall of ashes. The explosions ceased, and thinking that the disturbance was at an end we again retired, and most of the men had gone to sleep, when the loud rumbling was again heard, and before I could get out of bed an explosion of indescribable severity took place.

"On getting out of the tent I saw that smoke was coming out of the crater in dense clouds. Thinking there was going to be an eruption, I awakened the sleeping men, and wanted to vacate the camp, but we finally concluded to remain. The rumbling noise grew louder and louder, and then came a heavy report. I then saw the mud issuing from the crater as a cloud. In a few seconds I saw this cloud drifting across the lake toward our camp. Our camp was then swept by a heavy wind, which broke the tent ropes and threw the tent into the air. This atmospheric disturbance threw me a distance of about fifteen feet.

"Then there was a rain of ashes, which fell to the depth of about eight inches. The air was oppressive, and we had to gasp for breath; this lasted about twenty seconds. Then there was a light, warm shower of rain, followed by another fall of ashes, which lasted about half a minute. After this there was a cold, heavy fall of rain.

"By this time a tidal wave from the lake had reached our camp, a distance of about a quarter of a mile, and we took to a small hill about fifty yards away to the north, and waited for day to break. After daylight we returned to the site of our camp to recover what articles we could, but we found that everything had been washed away."

AN ALASKAN ERUPTION

In June, 1912, Katmai volcano, in southwestern Alaska, which had been generally believed to be extinct, unexpectedly burst into violent eruption and continued active for three days. Vast quantities of dust, lava, and stones were thrown into the air. So dense was the cloud cast into the sky that the people in the village of Kadiak, about one hundred miles away, were in total darkness for two days. All the crops of Kadiak were destroyed by the fall of ashes; the fishes in the sea and rivers were killed and all the water supplies poisoned.

Katmai is one of a long belt of volcanoes which extend for sixteen hundred miles. In this belt no less than sixty active volcanoes are

Courtesy of National Geographic Magazine. Copyright, 1913

FRAME STRUCTURE, CRUSHED BY WEIGHT OF ASHES AT KADIAK, ALASKA

When the rain of ashes and stone from a volcano buries houses a hundred miles distant, it is almost beyond our imagination to picture what must take place in the volcano itself.

known, among them Mount Wrangell, whose huge dome reaches a height of fourteen thousand feet; Mount Shishaldin, a graceful peak, whose outlines rival the Japanese Fujiyama; and Bogoslof, whose suddenly appearing and as suddenly disappearing islands have startled mariners for the past hundred years.

WHERE VOLCANOES ARE FOUND

There are many hundreds of volcanoes on the earth, though the majority of them are considered dead. Most volcanoes are in or near the sea, especially along the coasts of the Pacific Ocean. Many form chains or groups of islands like the Philippines, the Hawaiian Islands, the Lesser Antilles, and the Aleutian Islands. Scores of well-known islands like the Azores, the Bermudas, Cape Verde, and St. Helena are nothing but tops of volcanoes thought to be dead. Dead volcanoes are also found in great numbers in many of our western states, in Central France, and on the lower west bank of the Rhine. Even Great Britain bears traces of great volcanic disturbances. Nor is the earth the only planet to carry these scars. You remember that the dark places on the moon may be the craters of tremendous burnt-out volcanoes. The island of Hawaii is one immense volcanic mountain 30,000 feet from the bottom of the sea, with about one-half of its body out of the water. Magnificent Mount Shasta in California rises to a height of 14,380 feet. Three others in our hemisphere are notably huge: Chimborazo and Cotopaxi in South America are 20,000 and 19,600 feet above the sea; Popocatepetl in Mexico is 17,887 feet in height. All of these great cones wear snow caps which dazzle the beholder, and make him slow to believe that these snowy heads might at any time turn into roaring furnaces that would destroy life and the country for miles around.

KINDS OF VOLCANOES

Peculiarities of volcanoes are worth noting and remembering. Thus Vesuvius is an excellent type of the kind that shatters its original cone and builds another; while Etna is remarkable for breaking out into a family of little cones which cluster upon the slope of the main vent. Shasta stands as a beautiful example of a great snow-wreathed, extinct volcano. The craters of Mauna Loa and Kilauea, in Hawaii, are famed for their lakes of boiling lava, which every seven years or so overflow and move down to the sea in rivers as wide as two or three miles, and thirty or forty miles in length.

LAVA LAKES, STREAMS, AND FIELDS

Lava is the melted rock which is thrown out through the volcanic channels. When it comes out through the crater mouth, we can look down into the crater and see what appears like a lake of smoldering fire.

One of the most wonderful lava lakes in the world is that in the crater of Kilauea on the island of Hawaii. It is less than three miles across, and lies from six hundred to nine hundred feet below the rim of the crater. The surface of this sea of fire is usually covered by a thick crust, but here and there the red lava waves spurt up. Jets of vapor whistle and hiss as they escape, darting out showers of burning cinders, and forming cones of ashes on the crust sixty to one hundred feet in height.

The level of the fire lake of Kilauea is always changing. A fresh supply is ever forcing itself into the huge caldron, which now and then overflows. In 1840 the crater was full to the brink, when a crack suddenly opened in the side of the mountain; it sent forth a stream of lava thirty-seven miles long and sixteen miles wide clear down to the sea. At one point of its journey it poured down a cliff fifty feet high. Picture a red-hot stream forming a cataract as high as a house!

When first thrown out, lava flows. Some kinds of lava flow on steep slopes faster than a horse can gallop. Others are so slightly liquid that they move with extreme slowness and may continue flowing for years.

Before the red-hot flood has been long exposed to the air, it becomes covered by a dark-colored crust. Sometimes the liquid flows from beneath this crust, leaving tunnels and caves.

If the lava moves slowly, the pressure of the mass of liquid causes the newly formed crust to break into great blocks, which come to lie in roughened, tumbled heaps.

OLD LAVA BEDS, AND WHY THEY ARE ALWAYS DANGEROUS

Lava keeps its heat, so that when a crust has once formed on its surface, heat escapes from the inside very gradually. Even after a lapse of three or four years a lava stream may be seen to steam in many places after a shower of rain, showing that the lower part of the mass is still warm.

Of the thousands of volcanic cones in the world, only about three hundred are known to be active. These are mostly near the sea. But the great volcanic disturbances of the past have left great lava floods. Some of these came out through the mountain craters, and others through great cracks in the earth's surface. By these floods of melted rock, which flowed along valleys and wound around mountains, great sections of country were changed into lava beds.

In the valley of the Snake and Columbia rivers, an area of at least two thousand square miles in Oregon, Idaho, and Washington became first a sea of hot, glowing rock, and then a huge lava-covered plateau. Now it is one of the richest wheat belts of the United States. Yellowstone Park is a region of wonderful lava formations, where volcanic action long ago built up a fantastic area about fifty miles square, with acres of rocks of strange, unearthly shapes and coloring, and deep canyons and gorges of many hues.

KINDS OF LAVA

Lavas are of various kinds and colors. Perhaps pumice stone is the sort you know best. It resembles a sponge turned into rock. A lump of pumice will float on water. Large quantities of it drift down the Amazon River in South America, traveling often a distance of three thousand miles. And the Indians, living so far away from volcanoes that they do not know they exist, think that these floating stones are pieces of foam made solid.

A dark, heavy basaltic lava has built gigantic columns in many parts of the world. Popular belief has credited them to the handiwork of giants. The most notable example of this vast architecture is to be seen on the coast of Antrim, Ireland, where there are the summits of forty thousand prism-shaped columns, leveled pretty evenly by the waves of the sea. Some of the shafts of this famous Giant's Causeway are nearly four hundred feet in height. The Palisades of the Hudson near New York City are the edge of a lava flow.

International News Photo

LAVA FROM VESUVIUS BURYING A HOUSE

Mary Saint Albans Photo

PARICUTIN — A NEW VOLCANO

Erupting in the middle of a flat cornfield 200 miles west of Mexico City on February 20, 1943, Paricutin reached a height of 120 feet in three days, 600 feet in six weeks. At eight months a second crater called Zapicho (Indian for "little boy") occurred at the base. This picture shows Paricutin in the distance with smoke rising four miles high and the heavy layer of volcanic dust which has buried houses and ruined farmland for many miles around.

Ewing Galloway

THE GIANT'S CAUSEWAY

A marvelous formation of heavy basaltic lava. There are 40,000 of these prism-shaped columns.

HOT SPRINGS AND GEYSERS

IN all the volcanic regions of the world there are places where hot springs bubble up from the ground. All springs are thrown up by underground waters stored from the surface rainfall which has drained down. These have been stored near veins of hot lava or melting rock, which has heated them to temperatures varying from sixty degrees to boiling point. When these springs send columns of water and steam high in the air, they are called geysers. There are geysers in New Zealand, Iceland, and the Yellowstone Park, all volcanic regions. As the water rises, it brings up many mineral substances, so that the deposits around the hot springs are often brilliant in color. Sometimes geysers build cones, like a miniature volcano.

YELLOWSTONE GEYSERS

Yellowstone Park, in Wyoming, is the most wonderful of places in which to see geysers of all kinds and sizes, from tiny jets to living pillars of seething waters. In what is called the Upper Geyser Basin there are hundreds of hot springs in all phases of activity. "Old Faithful" is here, one of the most beautiful geysers imaginable, throwing its snowy stream to a height of from 125 to 150 feet every sixty-five minutes. Not far from it is the "Beehive," called so on account of the shape of its cone, which flings its water-plume as high as 200 feet. Then there is the "Giantess," which every two weeks performs for the sight-seer; the "Grand," whose exhibitions last for some time but are irregular in coming; and the "Giant Geyser," which is thought by many to be the finest in the whole Basin. It is erratic in its performances, but when they do take place there is no more sublime sight than the 250-foot shaft of foaming water leaping from the ground in seeming frenzy.

Elisha Gray, one of our foremost scientists, gave a striking word picture of one of these geysers in action:

"The geyser that produced the greatest excitement and enthusiasm of all was called the 'Grand,' which played once in twenty-six hours. When I saw it in action it was late in the afternoon, and, standing between the sun and the geyser, with my back to the former, I had the advantage of the reflected light, which is very bright in that high altitude. Close by the side of the geyser is a steam blowhole about six inches in diameter, and all about are a number of boiling springs that are connected with the geyser. Just before the play began all these springs were in great agitation in sympathy with the coming event. As a final preliminary, this steam blowhole started up, giving a blast of terrific power.

"The moment the steam trumpet made the announcement, the water in the top basin of the great geyser heaved several times as if unable to make a start, and then lifted itself up bodily for more than one hundred feet into the air. It took the shape of a beautifully formed evergreen tree whose branches cover the trunk down to the ground, the tips of which are loaded with cones set with purest diamonds. These cones shot out from the center on moving stems and burst into brilliancy at the limit of the tree-like form, producing an effect something like that of a rocket when it first bursts in the air, and before it has fully spread. Imagine thousands of these jets moving in all directions and bursting into beautiful colors, now vanishing and now others taking their places, till one is excited to the highest pitch by this wonderful exhibition of color, form, and motion. All the time Nature's great steam foghorn is sounding its thunderous note beside the geyser as if sympathizing with this mighty effort of pent-up energy.

"After keeping up this wonderful display for fifteen minutes it suddenly stopped, all but the steam jet, which seemed as vigorous as ever, and the water rapidly receded down the tube of the geyser till out of sight. In a few seconds the water was seen quietly but rapidly coming to the top, and when it reached there it suddenly burst into full form and height for one short moment and receded as before. It came back and receded seven times, and at each coming it made the same burst, until at the seventh pulsation the steam jet suddenly stopped, as much as to say, 'Gentlemen, the show is over.'"

A famous scientist, Bunsen, from whom our Bunsen burners are named, first found out the cause of geysers. He knew that steam from boiling water had a tremendous power of expanding. He also knew that the boiling point

Ewing Galloway

A GEYSER IN "THE VALLEY OF THE MOON," CALIFORNIA

of water was increased by pressure. So this was the way he worked it out: In a geyser, a column of heated water is standing in an upright tube, and is being heated at the bottom. At the bottom of a long tube such as forms one of these hot springs the boiling point would be higher than at the surface. At the bottom of the Great Geyser, for instance, the boiling point is 257 degrees, while on the surface with no pressure of water above it water boils at 212. We know how boiling water makes steam in our kettles, so that we must have a spout to carry it off. The steam made at the bottom of the tube pushes on the upper layers and sends them violently into the air. Bubbles of steam continue to push upward from the lower levels but, as they reach the cooler water above, they burst. In this way, the cooler layers are warmed. Finally, at each level, the water is heated to a different boiling point because of the difference of pressure at the various levels. If, at this time, some of the water is pushed out of the top of the tube by the expanding steam, the pressure is suddenly less throughout the tube. The water, which was heated just to its boiling point, is now boiling because of change of pressure. Violently the water bursts into steam, which shoots far into the air. The water is cooled in its eruption one hundred feet or more into the open air, and must be heated again after it has fallen back, before it will be hot enough to boil and be thrown up into the air again. This explains the regular intervals at which the geyser sends out its eruption. It also indicates the tremendous force that drives the water upward.

DeCou-Galloway

GIANT GEYSER, YELLOWSTONE NATIONAL PARK

TOP ROW: CASTLE GEYSER, YELLOWSTONE; LIBERTY CAP, MAMMOTH HOT SPRINGS
BOTTOM: GOLDEN GATE CANYON; GORGE OF THE AMMONOOSUC, NEW HAMPSHIRE

EARTHQUAKES

WHEN THE GROUND SHUDDERS

THERE is nothing more terrible to man than to feel the earth shaking under his feet. Even if the tremor of the ground is very slight, and does little or no damage, it is a sign that the solid earth on which he lives his life, and builds his houses and railroads and cities, is raised and lowered by some giant forces.

Our modern earthquake-reading instruments — *seismographs*, or "earthquake writings," as they are called — are so sensitive to the least vibrations of the earth's crust that they record many more of these tiny shocks than had ever been imagined before. Japan has hundreds of these shocks a year, and the people build their houses as light as possible, so that if they are thrown down the danger and loss will be lessened. In a single year, six hundred and thirty shocks were recorded in Japan.

WHAT CAUSES EARTHQUAKES

It has been well said that every kind of nature activity which produced our world can be seen going on in a small way now. Water is wearing away rock, heat and cold are contracting and expanding all kinds of solids, and gravitation is pulling everything towards the center of the earth. But nowhere is earth-making being done on so large a scale as in the great volcano and earthquake belts. Here we see the disturbances taking place, which once made mountains and hills and valleys, sea basins and continents.

Earthquakes are caused by the slipping or warping of the rocks of the earth's crust. The slipping of the rocks causes a shaking or vibration. The vibrations make an earthquake. It is stronger near the place where the rocks have been warped, slipped, or broken, near the "fracture," as it is usually called. Near by, the damage may be great. Buildings may be overthrown, pipes broken, roads and fences broken and twisted; while at a distance from the fracture, there may be only a slight trembling of the earth, hardly noticeable, and again it may be severe enough to shatter cities. The damage from earthquakes comes more from the vibration than from an actual shift of ground. Sometimes only a single shock is observed, and sometimes shocks may be repeated at uncertain intervals over a period of days or weeks. They are of more frequent occurrence than is realized, the crust of the earth being rarely free of some seismic disturbance.

The fractures along which slipping occurs are called "faults." Faults are commonly forty or fifty miles long. A famous one on the western coast of the United States has been traced for a distance of 600 miles.

THE CHARLESTON SHOCK

Earthquakes occur generally in volcanic regions or where it is mountainous. But there have been remarkable exceptions to this rule. One of these was the calamity to Charleston, South Carolina, on August 31, 1886. One present gave the following account: "As the hour of 9.50 P. M. was reached, there was suddenly heard a rushing, roaring sound, compared by some to a train of cars at no great distance, by others to a clatter produced by two or more omnibuses moving at a rapid rate over a paved street, by still others to an escape of steam from a boiler. It was followed immediately by a thumping and beating of the earth underneath the houses, which rocked and swayed to and fro. Furniture was violently moved and dashed to the floor. Every movable thing was thrown into extraordinary convulsions." Not a building in Charleston escaped injury, and almost fourteen thousand chimneys were broken off the roofs. The ground was cracked in places to a depth of many feet, and from these cracks sand was thrown out in large quantities.

THE SAN FRANCISCO EARTHQUAKE

The San Francisco earthquake, April 18, 1906, was another of the great disasters of modern times. A one-minute shock, with resulting fire, was sufficient to destroy the business and downtown residence section, including 28,000 buildings, with property loss of $500,000,000. The city was rebuilt with fine new buildings, and the beautiful San Francisco of to-day is a monument to the energy and constructive vision of her people.

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DESTRUCTION RESULTING FROM AN EARTHQUAKE

Though an earthquake is still an awe-inspiring force, its disastrous effects have been greatly reduced by modern engineering. Buildings are now constructed to withstand earthquake shock.

THE JAPAN DISASTER

One of the most destructive earthquakes of modern times occurred on September 1, 1923, in the eastern portion of Japan, covering a region of approximately 9000 square miles and wrecking to a considerable degree the cities of Tokio and Yokohama. Fires in the cities and high waves along the coast added to the horrors of this wholesale destruction. It was estimated that 200,000 perished in the disaster, while the homeless numbered two million. In Tokio it was said that of 500,000 homes only 122,000 remained standing, while in Yokohama only 27,000 remained of 96,000. Business sections, foreign embassies, and harbor equipment were in many sections literally wiped out. The United States led in enormous relief contributions, and the people of Japan went about rebuilding their cities with a splendid courage. Actual measurements show a drop of four feet, due to a strain in the earth's crust which finally caused the surface rupture.

SPEED OF EARTHQUAKES

Earthquake shocks travel at varying rates of speed, and experiments clearly show that the speed depends on the kind of rock or composition of earth through which the shudder passes. The velocity of the Charleston earthquake was marvelously rapid, — 17,008 feet a second. In Japan, earthquakes have been known to travel at about 5100, 8000, and 9800 feet a second, while other records, made in Italy, show the rate as low as 650 feet a second. Tidal waves, which are produced by earthquakes under the sea, have a speed of from 300 to 500 miles per hour.

THE EARTHQUAKE BELT

The most unstable belt in the world is that encircling the Pacific Ocean. This includes Japan, many of the Pacific islands, the South American earthquake region, and our own Pacific coast. The other great zone borders the Mediterranean and Caribbean seas, and goes through Central Asia and the East Indies. These two zones are the great volcanic belts of the world. On the whole, the earthquake regions bordering the Pacific Ocean border also steep-sided ocean deeps. The land seems to be rising, the ocean floor sinking. The surface of the earth moves about a great deal. Some parts of the earth are being pushed up. Others are sinking. This can be seen best along certain seacoasts.

Courtesy of U. S. Geological Survey

FENCE SPLIT INTO TWO SECTIONS BY EARTHQUAKE

In this case the displacement of the earth's surface caused by an earthquake had the effect of separating the fence in the way shown in the photograph. The distance between two broken ends of the fence is a measure of the force of the earthquake.

EARTHQUAKES AND EARTH BUILDING

When mountains are formed, the outside of the earth is warped, broken, and pushed together, just as if some giant pushed a lot of blocks around. Earthquakes are the result of the slipping, bending, breaking, or fracturing of the rocks of the earth when mountains are being built or parts of the earth are being raised or lowered.

THE OLD MAN OF THE MOUNTAIN, FRANCONIA NOTCH, NEW HAMPSHIRE

H. Armstrong Roberts

MOUNTAIN MAKING

THE GREAT FORCE WHICH MAKES LAND

" . . . But breathe the air of mountains
And their unapproachable summits
Will lift thee to the level of themselves."

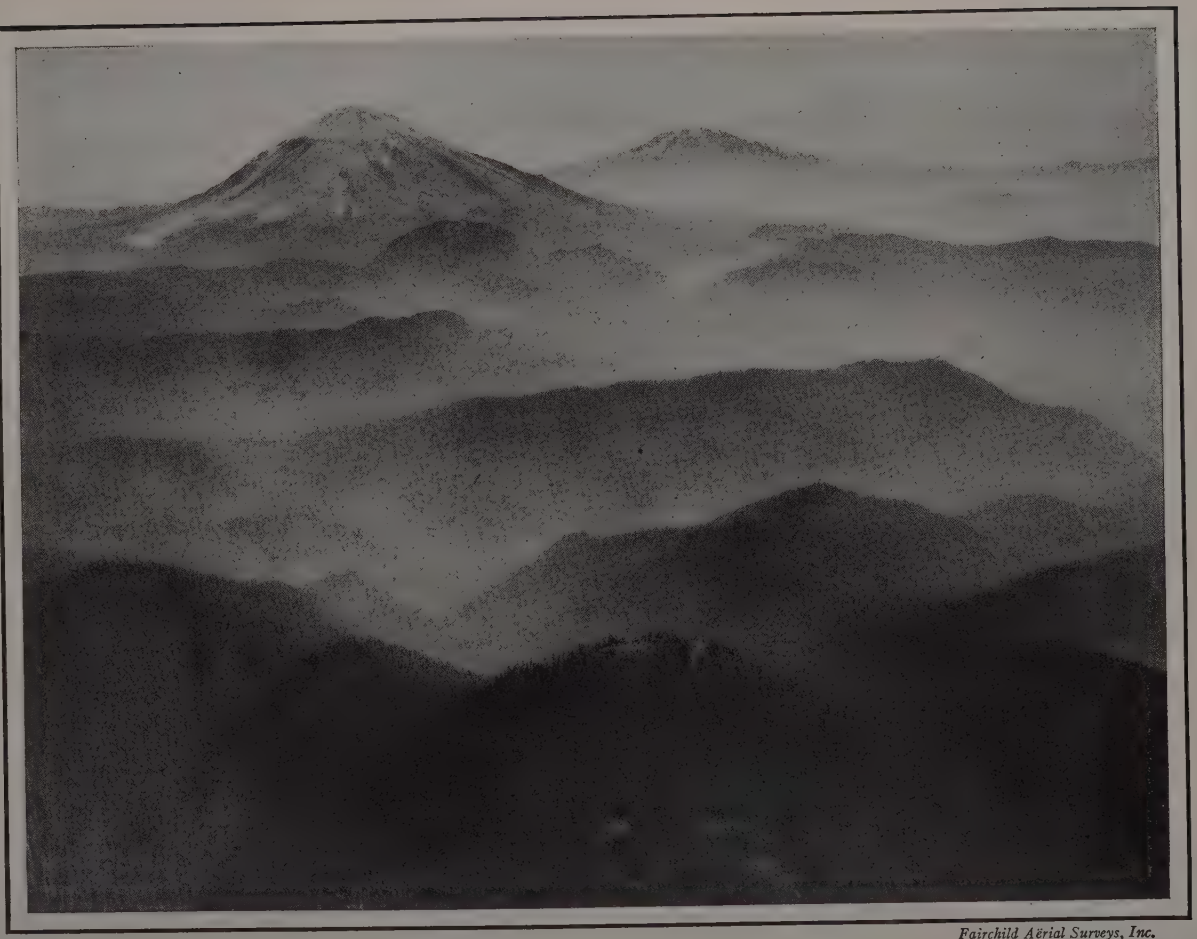
EACH of the five continents has its mountain groups or chains, which make the strong backbone for the plains that slope to the rivers or to the sea. These mountains have had a great deal of influence on the world's history. They separate countries, shutting off one nationality from easy communication with another. They change climate, standing as barriers to temper cold winds and to cool hot blasts. More than all else, they are great collectors and distributors of water. Often a moisture-laden wind is cooled so much by a mountain range that the rainfall is decidedly heavier on one side of the range than on the other side. The great rivers of the world have their sources high in mountain ranges. Mountain forests hold and protect the waters which are taken from the air in rain and snow and fog. The problem of conservation, now so much discussed in this country, is the question of how to save our forests for the sake of the protection they give to our great water courses. These in their turn make our lowlands rich and fertile, when otherwise they would be barren deserts.

MAN'S THOUGHT OF MOUNTAINS

When we think of mountains, we usually think not of their location or of their uses, but of their grandeur and beauty. If we live near great mountains, they come to have personality to us. We watch them as our friends, and know their outlines and their shades and lights by heart, as Ernest, in Hawthorne's story, knew the Great Stone Face in the Franconia Notch of the White Mountains. A mountain is never twice the same. Some days it will be clear and bright, again it will be wrapped in garments of mist, from which only the lower part stands out in even, shadowy outline. But always the mountains are majestic and unapproachable; always they give man a sense of a might and strength far beyond himself. "'The strength of the hills is His also."

So it was little wonder that in the childhood of the world men thought of mountains as the handiwork of the gods, who had either hurled them from heaven or built them to hold up the skies. When the gods had built them they would naturally use them as their earth homes. So imaginary Mount Merou was the throne of the gods of India as far back as man could trace. The peak of Lefeu in China, and the volcano of Fujiyama in Japan, are also sacred mountains. The Samanala, or Adam's Peak, in Ceylon, is reverenced as the spot where Buddha left his last footprint before he soared to heaven; and also as the place where Adam, barred out of Paradise, came to do penance. To the Armenians, Mount Ararat is a holy place. Olympus was the dwelling place of the gods of Greece; Parnassus of the Muses; and so we might go on with a list of sacred mountains of every land.

Certain peaks all over the world have especial interest, either because of their associations, or because of their unusual height. Mount McKinley, the highest peak in North America,



Fairchild Aërial Surveys, Inc.

MOUNT ST. HELENS AND MOUNT ADAMS, WASHINGTON

Seen from the air.

towering 20,500 feet above sea level, is familiar to us because of the many attempts to climb to its summit. We have a feeling of possession in our Rocky Mountains with their great national parks. It is a matter of national and continental pride that we need not go outside of the American and Canadian Rockies for some of the most majestic scenery in the world, while the Grand Canyon, the Yosemite, and the Yellowstone give unsurpassed scenic effects both of color and grandeur.

ZERMATT AND THE MATTERHORN

WILLIAM TELL'S LAND

Switzerland is, of course, the most famous mountain country. Situated in the heart of Europe, it is easily reached. It is picturesque beyond most mountain regions, because people live very high on the peaks. The Swiss have built their low-roofed châlets under overhanging cliffs and upon the high Alpine meadows. Switzerland shows every form of rock architecture, from the rugged tower of the Matterhorn to the great snow-capped dome of the Jungfrau and her sister peaks, and the lofty Monte Rosa, 15,217 feet high.

HOW MOUNTAINS ARE FORMED

In any mountainous country, there are many places in which the outer layers of the mountain-side have been in some way removed. Sometimes the slipping of a whole section of the mountain has uncovered the parts that were inside. By the study of such regions men have learned something of the structure of the mountains themselves, and have gained some idea of the kinds of forces that must have been at work when the mountains were made. The same forces that built and destroyed mountains in the past are acting to-day, but they work so slowly that only slight changes occur in the lifetime of one person.

WHAT HAPPENS IN MOUNTAIN MAKING

These layers once were straight. They were formed at the bottom of an ocean. Later they were tilted and bent into this shape, and lifted above the water to become mountains.

What are some of the facts that have been learned about mountain structure? No doubt everyone has seen, in the sides of canyons or cliffs, layers of rock lying one above another. A single one of these layers may be from a few inches to several feet in thickness. Sometimes the layers, or strata, show many colors. To those who know how to read their story, such rock layers as these announce that the materials which compose them were once sand or mud, and that the sand or mud layers were laid down, one upon the other, under water. In some places it was the water of the ocean which covered the

SNOW-CAPPED MOUNT RAINIER, MONARCH OF WASHINGTON

layers for thousands of years as the soil gradually hardened into rock. Often the hardening process went on under great seas which covered the interior of the continent. The varied colors resulted from the presence of different kinds of minerals.

When they were laid down, the layers were horizontal or gently sloping, but in the mountains they are arched alternately upward and downward, as if some great force or forces had pushed them into folds. No one knows what forces were mighty enough to lift into mountain ranges the land beneath the sea. But only by such an upward movement could the layers have become parts of mountain ranges. In some of these rocks are imprints and skeletons (fossils) of animals whose only home is in the sea.

Aside from strata, most mountains contain great rock masses which are not arranged in layers and which never show fossils. Such rocks moved into their present positions when they were so hot that they were liquid. Some of them cooled while they were still underground; others cooled after they had poured from some volcano. These rocks are very hard and are not nearly so easily worn away by erosion as are the other parts of the mountain.

Often parts of mountain ranges and sometimes whole ranges have been formed by the slipping of the earth along a fracture or break of the earth. Great blocks of the earth's crust have been raised in this way and have formed mountains.

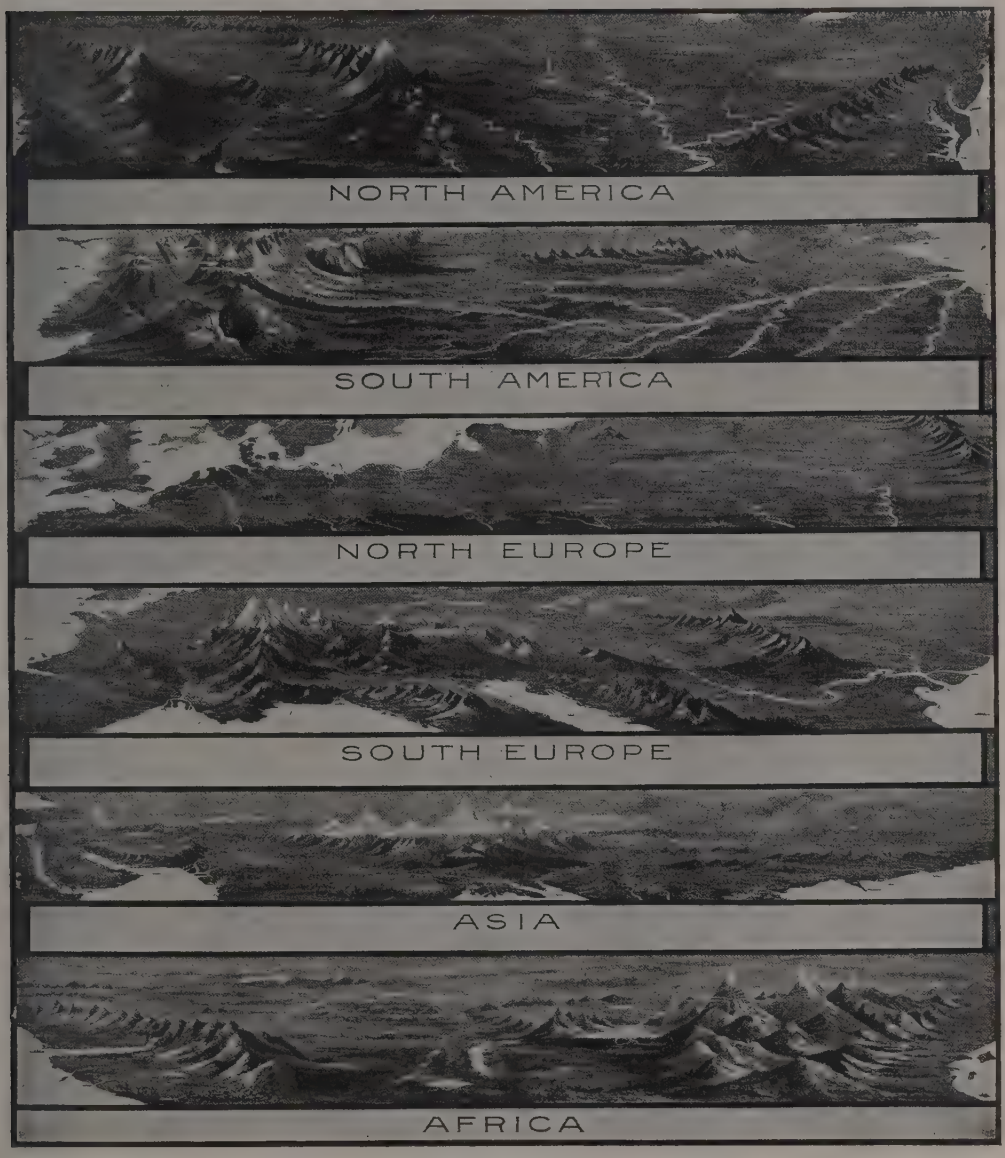
No mountain range remains the same from year to year. Rain falling upon its surface, streams flowing down its slopes, winds blowing its soil, cause continual wearing away of its softer parts. The running water carries the materials from the slopes to the more nearly level land near the base of the mountains.

It is quite probable that mountain ranges in the oldest lands have been uplifted and worn down more than once during the ages of the past.

Many ranges, but not all, run from north to south. Others extend from the land into the sea, making peninsulas, like Lower California and Italy. Still others, like the New Zealand and Hawaiian Islands, rise in the middle of the ocean. The continents owe their triangular shape to their mountain chains, which run from north to south, gradually coming together at the lower points.

As you look at the relief pictures of the continents you will notice that, besides the main

CONTINENTAL MOUNTAIN FORMATIONS AND WATERWAYS



EXPLANATION OF THE RELIEF MAPS OF THE CONTINENTS

1. Pacific slope; Sierras; Rockies; Plains and Mississippi Valley; Alleghanies; Atlantic coast.
2. Pacific slope; Andes; Long eastern slope; Amazon River; Parima Mountains; Atlantic coast.
3. British Isles; North Sea; Denmark; Baltic; North Germany; Russia; Ural Mountains.
4. France; Mediterranean; Alps; Italy; Adriatic; Danube; Carpathians; Bulgaria; Black Sea.
5. Red Sea; Arabia; Persian Gulf; Ganges; Himalayas; Burma; China; Yangtze; Yellow Sea.
6. Atlantic; Congo; Coast Range; Lake Lincoln; Central Africa; Lake Albert; East Coast Range; Indian Ocean

THE ROCKY MOUNTAINS IN COLORADO

Showing Marshall Pass, the Great Continental Divide.

ranges, there are secondary ranges, which are shorter and lower than the great chains which give the continents their shapes.

The highest mountains of the world are in the principal ranges of each continent: in the Rockies in North America, the Andes in South America, the Alps in Europe, the Himalayas in Asia, and the extensive chains of Africa and Australia.

AT THE TOP OF THE WORLD

Switzerland is the region about which poets have written and singers have sung, but it is not the highest part of the world. To find that, we must go to Central Asia, to the plateau of Pamir, which has been called "the roof of the world." Here three great mountain chains take their beginning. This triple wall of Asia is about fifteen hundred miles long and six hundred miles wide. In each of the three chains the average height exceeds that of any other ridge in the world. Here, too, the three great rivers, the Indus, Ganges, and Brahmaputra, have their sources.

Of these three mountain chains the most famous is the Himalayan. Its tallest peak, Mount Everest, is 29,141 feet high, the highest mountain of the world. You will notice that it is nearly twice as high as Mont Blanc, and a third again as high as Mount McKinley in Alaska.

CLIMATES OF MOUNTAINS

With their base in the tropics and their head in the clouds, the Himalayas have at varying heights almost all the climates of the world. The lower valleys are filled with flowers and tropical growth; farther up the climate becomes more like the temperate zones of the world, and for the last two miles of their height, which are above the freezing line, there are the great snow fields and glaciers and ice formations which give the range its name, Himalaya, "the abode of snow."

MTS. WILBUR AND MCDONALD, IN THE CANADIAN ROCKIES

Ewing Galloway

DESERTS

SCATTERED all over the world, but especially in the southern continents, there are great deserts, barren stretches of waste land where there is little or no vegetation. These are the unused sections of the globe. A few tribes of the East make their homes upon them, as you will see when you read about the Bedouins; but in general men do not live on these great dry plains.

WHAT MAKES A DESERT?

A desert is caused by absence of water. In some parts of the world rain falls so seldom that whole districts are practically rainless. Here we find the great deserts, because, no matter how fertile the soil, vegetation cannot grow unless there is water. Many regions report an average rainfall of less than two inches in a year, and still more have from two inches to ten. These desert lands stretch in a wide belt both north and south of the equator, extending round the globe. Beginning in the Desert of Sahara in Africa, the "world's oven," as it has been called, the belt goes across by Arabia and Persia to Mongolia, then across the dry sections of Australia to the Desert of Atacama in South America. Not all the deserts of the world lie in this hot equator belt. Our own western states and many countries farther to the north and south of the equator have their smaller dry sections. These are usually walled in by mountains, which act as natural barriers to keep out the moisture which would otherwise blow over the plains and make them fertile. High ranges near the sea will often have beautiful green valleys on their outer slopes and barren stretches of sand within. Our high mountain chains on the Pacific coast are the chief cause of the desert region immediately east of them. They stop the winds from the ocean and leave the lands to the east dry and arid, until our modern systems of irrigation supply the thirsty land with the moisture needed to make it fertile.

Not only mountains but the heat of the sun keeps the lands near the equator dry. The trade winds which blow over these desert regions have so little moisture that they pick up all the water they can from the land beneath them. So in the world's great desert belt the winds are as likely to take away moisture as to bring it.

WHAT WE OWE TO WATER

We who live in the United States cannot easily appreciate what it would mean to live in the dry sections of the world. Our country owes much of its prosperity to its steady rainfall and the rich water supply stored in mountains and rivers. Air and water are two essentials to life. A man may live for a month without food, but he cannot exist a week without water.

In the East, water is so precious that it is sold on the streets. Women must go long distances to wells and carry laboriously to the homes the small supplies which they need. Perhaps no one cause is more responsible for the

differences between Occidental and Oriental life than the abundance of water in the West and its scarcity in the East.

THE DESERT LIKE THE OCEAN

Deserts have often been compared to the ocean, and in many ways they are not unlike. The wind tosses the waters of the ocean into waves, and the sands of the desert into great billowy dunes and ridges, which make it look from a distance like a vast white ocean. The waters and the sand are both, strange as it may seem, salt. The waters of the sea are about equally salt from pole to pole, while the sands of the desert vary in saltness. Both ocean and desert are closed basins, shut in by shore or mountains, with no natural outlets, and little to affect their surface save the air above them. And man, while he can travel across both, can make a permanent home on neither.

THE SAND-SWEPT, ROCK-STREWN, GREAT DESERT OF ARABIA

WHAT THE AIR DOES TO THE DESERTS

Air cannot protect the desert surface from the sun's rays, as it might if it were more moist and could temper the heat and light by banks of cloud. So the desert is very hot. Temperatures of one hundred and eighty degrees Fahrenheit have been reported from the deserts of Africa and Arabia. Because there are no clouds to hold the sun's heat, there is a remarkably sudden drop of temperature at sunset. Regions where the thermometer has stood at one hundred degrees and over for the greater part of the day will be so cold during the night that water will freeze. Many of our deserts were originally fertile lands, which became barren because of the absence of water on their surrounding mountains. That is why people fear so much the cutting away of forests from our great mountains. As the water ceased to be held by the trees and mountain streams, and the mountains stood out bare and rocky, the lowlands soon became dry and unfit for farming. Then clouds ceased to form in the highlands and float down over the plains; the hot sunlight beat down without ceasing, parching the land and disintegrating the rock, until at last there was only a trackless desert.

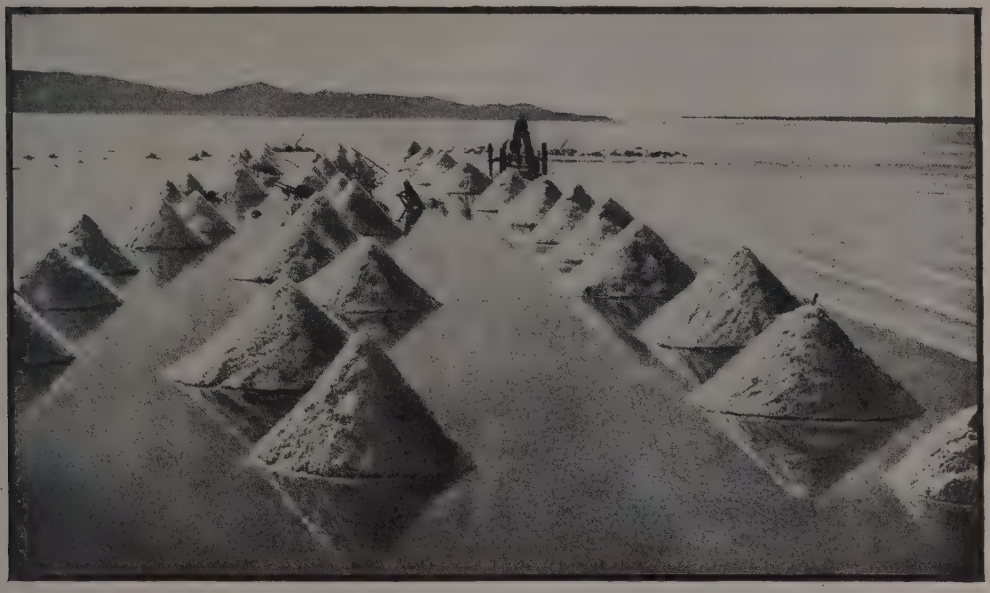
The most important stretch of desert land on the earth is the Sahara, which reaches across

Fairchild Aerial Surveys Inc.

CANAL PROJECT, YUMA, ARIZONA

Water brought to the desert brings vegetation along the borders of the canal. For the story of "Irrigation," see Volume IV, pages 365–374.

Africa from the shores of the Atlantic to the Valley of the Nile. Imagine a vast waste of sand stretching three thousand miles across the United States, from Maine to California, and six hundred miles from Chicago on the north to Birmingham on the south, and you will get some idea of the extent of the Sahara. This desert was once the bottom of a sea, as were most of our inland plains. While the average height of the Sahara is about two thousand feet above sea-level, in one place it is one hundred and sixty-five feet below, which shows that it might easily have been a deep ocean basin. Few deserts are the flat stretches of sand which we are accustomed to think them. In the midst of the Sahara there is a range of lofty mountains, snow-covered during part of the year, dividing the desert into two parts, on both sides of which are lines of lower shifting sand-hills. In the Gobi Desert of China, the eastern part of a great 1,850-mile sand plain, are cliffs which show the beating of ocean waves, wearing them away thousands of years ago, before the waters sank back into our ocean basins, and the land was left high and dry. In the Andes there are long plateaus which rise above one another between the sea and the highest mountains. The Atacama Desert, the largest in South America, is a vast expanse of reddish-colored rocks, with blowing sands between.



SALT HEAPS GATHERED ON THE SHORE OF THE GREAT SALT LAKE IN UTAH
The water is so buoyant that one cannot sink in it, and swimming is a comical sight.

TRAVELING HILLS

We think of deserts as sand plains, but they are not all level reaches of sand. In our own country there are great clay and rock formations, making the dry stretches look like cracked plains of concrete. There are fields of crystallized salt in Utah, and miles of sandstone and limestone in the Bad Lands of Wyoming; but the gradual wearing down by wind and weather has reduced many of the desert surfaces, and especially those of the south, to fine shifting sand, which the wind may toss where it will. Even on quiet days the wind is at work picking up these bits of sand and carrying them along. On windy days, or when one of the fearful wind storms comes on the desert,

By courtesy of Travel

AT A DESERT OASIS

it will pick up a hill of sand and whirl it away, casting it down in a new place.

OASES AND DESERT PLANTS

Fortunately for man, deserts are not unbroken stretches of sand. They are dotted here and there with beautiful green spots, where water gushes from springs or comes down from the mountains in streams, making a fair green island in the ocean of sand. Here date trees, apricots, peaches, and pomegranates may often be seen. Here man may find comfort and coolness in the heat of the day. Sometimes these oases come at irregular intervals, dotted over the plain. In the Desert of Sahara they form a line in the middle of the open section. So the traveler can pursue his journey across in a fairly straight path, with palm-waving stations every little while. Man has succeeded in boring wells in many places, too, and these spots have become groves and gardens, so that the desert has lost its terror.

In some desert regions there are plants which depend for their water supply not upon the springs of an oasis, but upon the scant rainfall of the desert itself. All of these plants are adapted in one way or another to live with almost no water. Some of them, especially the cactus, store the water which they obtain from the few rainfalls which do occur. The water is stored partly in sections of the stem which have become broadened like a very thick leaf.

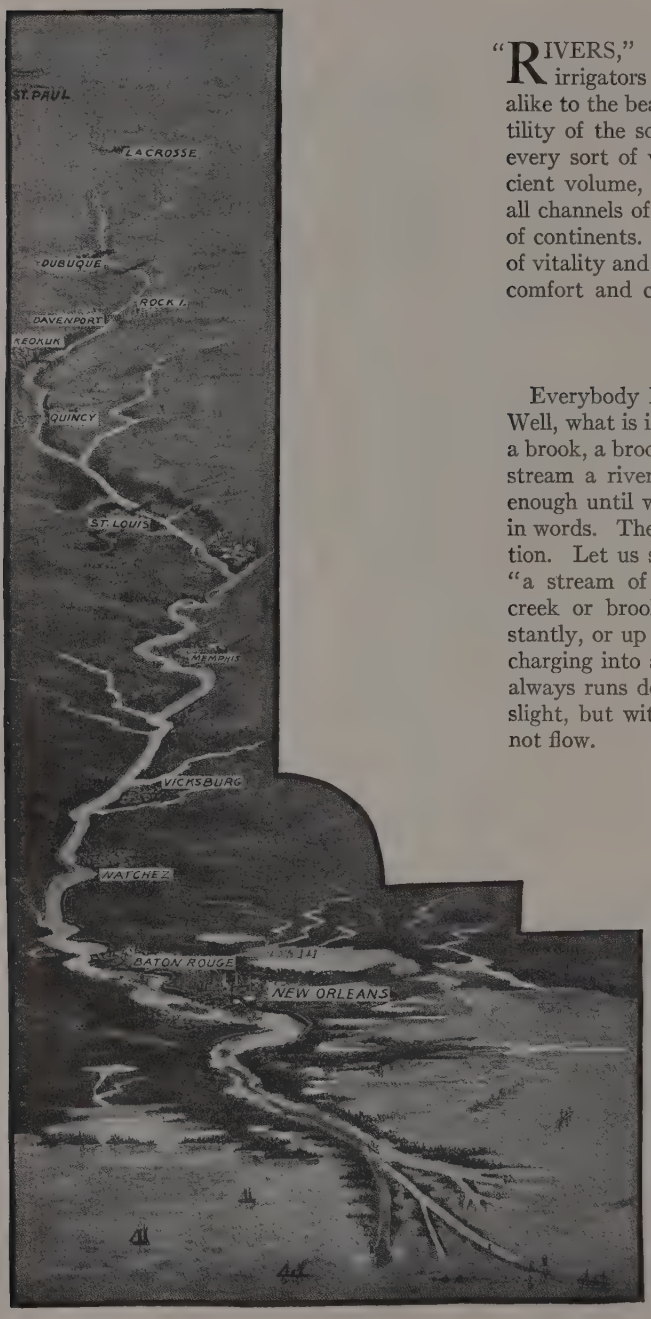
Many of the plants depend not so much upon storing an extra supply of water as upon preventing the evaporation of the small supply which they have. Since water is evaporated largely through the leaves of a plant, its escape is prevented if the plant has very small leaves. In the cactus the leaves are reduced to thorns. Many of the desert plants bear beautiful blossoms.

A rain will make some deserts a garden of flowers in a short time. Many seeds, roots, and bulbs, are buried in the sand, ready to grow as soon as there is enough water.

Publishers' Photo Service

A MEXICAN SCENE, ON THE ROAD TO MONTEREY

Showing desert vegetation.



THE MISSISSIPPI IN ALL ITS LENGTH

A large, swift-flowing current such as this can carry a great deal of soil to the sea. The Mississippi carries more material to the Gulf of Mexico than can be carried by all the freight trains which enter Chicago. Chicago is supposed to be the greatest railroad center of the world.

RIVERS

"RIVERS," says a great writer, "are the irrigators of the earth's surface, adding alike to the beauty of the landscape and the fertility of the soil; they carry off impurities and every sort of waste matter; and when of sufficient volume, they form the most available of all channels of communication with the interior of continents. . . . They have ever been things of vitality and beauty to the poet, and agents of comfort and civilization to all mankind."

WHAT IS A RIVER?

Everybody knows what a river is, of course. Well, what is it? When does a brooklet become a brook, a brook a creek, a creek a stream, and a stream a river? These things all seem simple enough until we really try to tell the difference in words. The dictionary will give you a definition. Let us see what a river is, in law. It is "a stream of water larger in volume than a creek or brook, flowing in one direction constantly, or up and down with the tide, and discharging into a larger body of water." A river always runs down a grade. The grade may be slight, but without some slope the river would not flow.

High grades at some points make a pressure that carries the current along in more level spots. The river speed depends upon its slope and volume. Usually a number of brooks and creeks unite and make a volume of water sufficient to be regarded as a river. There is no fixed measurement, however, and in some portions of the country streams are called rivers that would be known as creeks in other sections. A creek is a small river, and local pride thinks "river" a finer word than "creek;" so a river it becomes.

Only when we turn from the dry, barren deserts of the earth do we appreciate the blessing of running water. If our earth were flat, with no mountains or valleys, no sloping country or hollow basins, there would be no rivers or streams. Water would stay where it fell, or sink at once into the ground.

Rivers arise because of differences in level between neighboring sections of the country. The water flows towards the lowest level which it can find. If there were no slope, that part of the rainfall which did not soak into the ground would stay on the surface as a lake. As the water flows down the slopes, it finds its way into cracks and hollows. Gradually soil is carried away from the bottoms and sides of these hollows. In this way, the river carves for itself a bed which becomes steadily wider and deeper until a valley forms. At first, the sides of the river valley are steep. In time, its sides are worn down until the valley is broad, and has gently sloping sides.

THE SHAPE OF A RIVER BED

If you were high enough above the earth in an airship, and could clearly see a vast expanse of land beneath you, you would get a wonderful picture of the way a river is fed by the various streams which flow into it. It would look like an immense tree laid out flat. The Rhine and the Mississippi might make you think of a majestic oak, while the outline of the Nile would put you in mind of a palm tree. Rills and brooks you would see as twigs, larger streams as branches, and the body of the river as the trunk of this watery tree.

Each of the great rivers of the world has a character all its own. It may be broad or narrow, calm or rapid, straight or crooked, deep or shallow, muddy and sluggish, or filled with rocks and waterfalls.

THE GREAT DAM IN THE SHOSHONE RIVER

The use of waterpower by means of dams is discussed in Volume Four.

FLOOD SEASONS

The amount of water in a river depends on the size of the region for whose waters it is the outlet. If this region be large, with many lakes and streams and steady rainfall, the river will be large. Some rivers are very even in their flow. The rainfall of their country is fairly steady, and the water is quickly and evenly distributed. But others are in regions where much water is stored during the winter in snow and ice on the mountains. In the spring this melts fast and floods the river till it flows out far over its banks. A heavy rain will turn a quiet mountain stream into a raging torrent. Where forests have been cut down on the slopes of the river basin there are likely to be floods. The rain is less likely to soak into the ground; there are no roots or trees to hinder its passage. So it flows easily down the surface slopes,

TVA Photo

A BADLY ERODED HILLSIDE, THE RESULT OF DEFORESTATION

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THE UPPER DANUBE

Here is shown in striking fashion the fertility that a river contributes to neighboring soil. The thrifty Germans make the most of every foot of this rich area.

and sweeps on over the plains below. Wooded slopes are one of the best forms of insurance which a nation can carry against destructive floods.

The first move of settlers in a new country is to clear the land of timber. This enterprise is undertaken partly for the sake of agriculture and partly for the harvesting of a crop of timber for building purposes and for fuel which will bring quick returns to the settler. Unfortunately the process is always carried on too long, and there comes a time in the history of every nation when it must turn its attention seriously to the problem of conserving and restoring its forests. In this twentieth century the United States has come to a partial realization of the dangers of denuding its surfaces of their natural covering of trees. Not only is the Government taking hold of the matter through its able and efficient Forestry Service, but states and organizations of private individuals are making careful surveys and instituting campaigns for local tree planting. Should we need an incentive, we need only turn to the reports of experts who have studied the effects of deforestation in other lands. "The reckless and wanton destruction of forests has ruined some of the richest countries on earth," writes one traveler. "Forests have an immense effect on climate," says the English observer, Sir Ray Lankester, "causing humidity, and similarly causing moderate and persistent instead of torrential streams. Spain has been irretrievably injured by the cutting down of her forests in the course of a few hundred years. The same thing is going on to a disastrous extent in parts of the United States. Whole provinces of the Tibetan borders of China have been converted into uninhabitable sandy deserts, which centuries ago were fertile and well watered and supported rich cities, apparently in consequence of the reckless destruction of forests."

Forestry has been defined as "the economic management of trees as communities." There can be no doubt that a "community of trees" conserves moisture. The ground which is protected from the intense heat of the sun's direct rays holds water and stores it. If water can seep down into the river channel gradually, there will be less likelihood of a sudden torrent on the mountainside which would rush down

FATHER NILE, FROM A FAMOUS SCULPTURE

and make the river at the bottom overflow its banks.

THE FLOODS OF THE NILE

We are apt to think of floods as a calamity, sweeping away homes and destroying crops. But in some of the less well-watered parts of the world they are a great blessing. In Egypt, after a long dry season the Nile begins to rise, flooding over two thousand square miles of land, and leaving behind, when its waters drop back to their regular channel, a fertile valley covered by a rich, thick, black mud in the place of a barren desert. The annual rise of the Nile is from thirty-eight to forty feet, and comes in the summer months.

The Egyptians worshiped the Nile as a sacred river, which gave yearly to those who dwelt on its banks this wonderful gift. Father Nile was a kindly god who brought them blessings of fruit and flowers.

The reason for this yearly flood was a mystery to them, but in our own day it has been found that this forty-foot rise of the waters is due to the melting of snow on the mountains of Ethiopia, where the Nile has its source, more than four thousand miles away from its mouth on the Mediterranean.

Rivers which regularly overflow, commonly build low ridges along their banks. This is because the water begins to move more slowly as soon as it leaves its bed. As a result of this checking of its speed, it deposits the heaviest part of its load almost immediately. Beyond this ridge, the water deposits its finer silts and muds, causing the land to slope gently away from the river.

THE SWIFTLY FLOWING JORDAN

A traveler once said that there may be something on the surface of some other planet to match the Jordan, but there is nothing on this, and we may believe it when we consider that this river extends only about 115 miles in a straight line and has a fall of 3,000 feet. The word "Jordan" is a Hebrew word, and means "that which goes down," or "descender." But this is not the only peculiar thing about this remarkable river. It receives its supply of water from three never failing springs on the cool, green slopes of Mount Hermon, the highest peak in Palestine, and flows down through a deep gorge into the hottest, driest,

OX LIVER GORGE AND RAPIDS ON THE YANGTZE RIVER, WEST CHINA

and lowest depression on the face of the earth. It twists and turns so much that its actual distance is about 250 miles. It flows through two bodies of water — Lake Huleh and the Sea of Galilee. Just below Lake Huleh the river reaches sea-level, and then, in a distance of less than ten miles, it fairly tumbles down in cascades and whirlpools, and flows furiously into the Sea of Galilee, nearly 700 feet below sea-level. It is said that it flows with such force that it passes through the lake in a straight line without mingling with its waters. Outside of the Jordan valley there is no place on the earth's surface so low as the Sea of Galilee, but in the southern part of Palestine lies the Dead Sea, 600 feet lower. And through a wild, deep gorge, lined with tangled jungle or chalky cliffs, the Jordan still goes down, and pours into the Dead Sea 6,500,000 tons of water daily. The river itself swarms with fish, the banks are musical with the song of birds, and wild beasts lurk in the thickets.

Explorers have tried to sail down this tumbling river, but have never been able to get through. A short distance above the Dead Sea, near the ancient city of Jericho, is a shallow ford in the river, where thousands of pilgrims go every year to bathe in its sacred waters, for the Jordan has always been a sacred stream both to Hebrews and Christians, and its shores have been the scene of many historical events, endeared to millions of people the world over.

CHINA'S RIVERS

China has two great rivers — the Yangtze (meaning "Son of the Sea"), which is the largest of the country, about 3,500 miles long; and the Hwang-ho, or Yellow River, which, though 1,200 miles shorter than the Yangtze, is known for the harm its floods have done. Unlike the kindly Nile, its floods bring death instead of life. Hence it has been called "China's Sorrow" and "The Scourge of the Sons of Han." In 1877 the Hwang-ho burst over its banks and drowned nearly a million natives. In 1898 it overwhelmed 1,500 villages. But the Chinese are finally conquering this river by providing a chain of canals into which the raging torrents of water may be turned and made use of in irrigating the land. The Yangtze is a river of more even flow, and is the chief commercial waterway of China. It is famous for its rapids and gorges, which make the westward

passage dangerous and often impossible in the rainy season. Both these streams have their sources in the Himalaya region; both run in a vast semicircular line, first in opposite directions, then meeting to flow together to the sea through an enormous delta, or group of mouths, 96,000 square miles in extent. This delta was built by the mud which the Hwang-ho constantly carries down from mountain and plateau. It has been calculated that the Hwang-ho brings down enough material yearly to build a pyramid one mile square and a little less than half a mile high.

PILGRIMS BATHING IN THE SACRED WATERS OF THE GANGES

INDIA'S GREAT WATERWAYS

The four most important rivers of India have their sources at nearly the same point, flow in opposite directions, and after making enormous circuits unite in pairs — the Indus and Sutlej to the east, the Ganges and Brahmaputra to the west. They represent to the natives of India four legendary animals — an elephant, a stag, a cow, and a tiger — which sprang down from the same mountain peak into the green plains of Hindustan.

But the noted river of India is the Ganges. Like the Nile, it is a sacred stream, and the whole Hindu mythology centers round it. On account of its size and its close connection with the life of the people, it is certainly one of the most interesting rivers on the globe. Its sources are in the Himalayas, its mouths in the Bay of Bengal, 1,500 miles away. Starting at an elevation of 13,800 feet, it became entangled in the hair of Siva on its descent from heaven to earth. At least, that is what the sacred story says. What it actually does, is to issue from under an immense bed of snow piled up between three peaks from a height

of 13,800 to 22,000 feet. It rushes forth in wild torrents, joins another river, and after traveling down grade more than 12,000 feet in a course of 160 miles, enters the vast plain of Hindustan. From this point it bears on its broad bosom ships and craft of every description, and is the splendid highway through one of the most fertile and thickly settled portions of the earth. The large cities of Calcutta and Benares are on its banks. In front of the steps of the quays at Benares, even in the dry season, the river is almost fifty feet deep. It has many shallows, however, and cuts new channels continually. One season it forms shoals, and the next season sweeps them away, altering its banks from year to year. Its delta begins about two hundred miles from the sea, and forms a wilderness of creeks and rivers, some of which are salt, while all of them are affected by the tides. According to the poet, the delta was formed by Siva squeezing the water from his hair and letting it run out between his fingers; but the less poetical fact is that the delta of the Ganges, like all deltas, was formed by the mud which the river carries along with it, and which is so immense in amount that its annual average is said to be over 534,000,000 tons. From May to November this extensive tract of low, flat land is one vast sheet of water, on which large vessels and small boats, steamships and rafts, swarm and float rapidly along. When the waters lower in November it is found that acres of land have been carried away and other acres formed. Sometimes large islands are made in this way and attach themselves to the mainland, while the river cuts a new channel, perhaps miles away. Thus, thirty-five years ago the city of Rajmahal stood on the river bank; now it is seven miles off. Land-owning is uncertain on this delta.

THE AMAZON

We usually think of the basin for which a river is the natural water outlet as a fairly small region, perhaps fifty or one hundred miles square. But picture a river whose basin is two-fifths of a continent! Such a river is the mighty Amazon in South America, which drains two-fifths of the whole continent, and is thirty-five hundred miles long. Its sources are two smaller rivers, which rise high in the Peruvian Andes, and it flows almost across the continent, emptying into the Atlantic through a mouth two hundred miles wide. The Amazon carries to the sea a volume of water vastly greater than that carried by any other river.

THE MISSISSIPPI, FATHER OF WATERS

We need not go outside our own country for great rivers. Much of the life as well as the beauty of the United States depends on its waterways.

The Mississippi, named by the Indians "Father of Waters," is the greatest river of North America. Rising from a little lake in northern Minnesota, it flows southward for twenty-five hundred miles and enters the Gulf of Mexico, having drained in its journey about two-fifths of the United States. About midway of its course on the west it receives the giant Missouri ("Muddy Water"), its greatest tributary, which has traveled from far-distant sources in Montana and Canada, making the Mississippi the longest water course on the globe.

The upper Mississippi flows for the most part through a narrow, picturesque valley, which broadens out to the southward into a low, fertile plain.

It is easy to understand the importance of this great river in the history and development of our country. Not only do its rich lands produce the most bountiful of crops, but it has been from the earliest times a great highway of trade and travel, from north to south, through the heart of the United States. It is interesting, too, to notice that it forms parts of the boundaries of ten states.

A RIVER OF ROMANCE

The Mississippi is indeed a river of romance and adventure. In 1542 De Soto, the Spanish explorer, reached it after a long and fearful march through the southern wilderness — only to die and be buried deep in its mighty bosom by his sorrowing followers.

In the seventeenth century, Frenchmen from Canada, including famous missionaries like Père Marquette, were braving untold dangers and hardships in the effort to discover and

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RAPIDS OF THE LOWER MISSISSIPPI NEAR NEW ORLEANS IN THE SPRING FLOODS

explore the mysterious "great river" of which the Indians had told them. Louis Joliet and Père Marquette were the first to reach it; while La Salle, a few years later, explored the lower Mississippi all the way to the gulf.

The Mississippi is fed by two hundred and forty good-sized rivers. Toward the south, as we have seen, it flows through a wide, flat plain, which is lower than the river at full tide. Taking also into account its enormous length, it is not surprising that floods are frequent. One of our national problems for many years has been the control of these overflowing waters, which are liable from April to July to do terrible damage. Levees or protective banks have been built along the shores, and dams and systems of canals have been constructed. Since these have failed to prevent the floods, new plans are being worked out. Great engineers declare that we have been working along the wrong lines, in trying to confine the swollen river by high jetties and levees; that Nature has really provided the great valley of the Mississippi with the best of gifts, when human nature learns how to use it. Like the Nile, this great watercourse can fertilize the farm lands on both banks if the spring floods can be directed into channels made for that purpose. These engineers are working out plans for floodways, so that instead of wasting these waters, rich in sediment, where they do damage to health and property, we shall distribute them over the whole Mississippi Valley, until the river becomes one of the great irrigators as well as channels of communication of North America.

THE LORDLY HUDSON

No American river is better known than the Hudson. Rising in the Adirondack Mountains, it flows through New York State from north to south, emptying into the Atlantic in the harbor of New York. Near its mouth on the New Jersey shore are the beautiful Palisades, made by sheets of lava deposited between the layers of the rock.

The river was discovered in 1609 by Henry Hudson, an English navigator in the service of the Dutch, who was trying to find a passage to India by way of North America. This gave the

Dutch their claim to the beautiful valley, which was called New Netherlands, until turned over to the English in 1664.

The first successful steamboat journey in America was made on the Hudson in 1807 by the *Clermont*, built by Robert Fulton, which steamed from New York to Albany — considered a most wonderful trip.

A most interesting fact regarding the Hudson is that it is a "drowned" river. Scientists tell us that ages ago the valley through which it flowed extended out into what is now the Atlantic Ocean, seventy or eighty miles eastward of Long Island, but that the lowering of the land caused the ocean waters to rush in and "drown" it. The tides can now be felt as far north as the city of Troy, a hundred and sixty miles from the mouth of the river; and the water is sometimes salt as far up as Poughkeepsie, seventy-five miles from New York.

The whole Atlantic coast is lower than it once was. The sea has invaded the mouths of several of the rivers, forming bays. Chesapeake Bay and Delaware Bay are typical drowned rivers. These are not true rivers, but really arms of the sea. The sinking of the Atlantic coast has made many good harbors along the shore of the United States and Canada.

THE ST. LAWRENCE

The St. Lawrence, forming part of the boundary line between Canada and the United States, is another great and important American waterway. Rising in the highlands of Minnesota, it flows onward through the chain of the five Great Lakes, and finally empties into the Gulf of St. Lawrence, forming altogether the greatest system of inland navigation in the world.

It is interesting to know that these same Great Lakes were themselves river valleys uncounted ages ago, until mighty glaciers from the north bore down upon them, clogging up the courses of the rivers, and turning them into what we now find them — great basins of fresh water.

After emerging from Lake Ontario, the river is broken by numerous cataracts or rapids. "Shooting the rapids" has always been a thrilling and sometimes dangerous incident of navigation on the St. Lawrence; but the cata-

A DANGEROUS DIVERSION — SHOOTING THE RAPIDS

By Burton Holmes from Ewing Galloway

THE SEINE RIVER, PARIS, FROM THE ROOF OF NOTRE DAME CATHEDRAL

racts can now be avoided by the use of the great canals which connect Lake Ontario with Montreal.

FAMOUS SPOTS ON THE ST. LAWRENCE

Everyone has heard of the "Thousand Islands," which are actually about fifteen hundred charming and picturesque islands in the St. Lawrence, lying between New York State and the province of Ontario. They are favorite summer resorts and are dotted with beautiful summer homes.

Passing down the river, we come to the great city of Montreal, head of ocean navigation on the St. Lawrence. During the season of open navigation, from April to December, its splendid harbor is crowded with ships from foreign ports. Farther on we reach Quebec, situated on a steep bluff and commanding one of the finest views in the world. The citadel of Quebec is the strongest fortress on the American continent. In 1759 it was taken from the French by the English under General Wolfe, in a great battle on the Plains of Abraham above the city.

OTHER INTERESTING FEATURES — PORTAGES

At Quebec the river widens into an estuary or arm of the sea, extending four hundred miles to the Gulf. The original valley of the St. Lawrence reached far out into the ocean, this being an even more remarkable example of a "drowned" river than the Hudson.

The watercourses of those two great rivers, the St. Lawrence and the Mississippi, approach so near each other in places that in the old days Indians would pass overland in their journeyings from one river system to the other, carrying their canoes on their shoulders. The trails they made were called "portages," and were much used by the white settlers and Jesuit missionaries, enabling them to travel immense distances in their canoes. Thus we see the great geographical importance of the two rivers, both separately and in connection with each other, and realize how deeply they have influenced the history and prosperity of our country. Lovers of history will not forget that Champlain founded Quebec in 1608, and discovered Lake Champlain.

Courtesy of Canadian National Railways

THE CITADEL OF QUEBEC ON THE PLAINS OF ABRAHAM

Ewing Galloway

THE BOLD CLIFFS ALONG THE COLUMBIA

THE COLUMBIA

The great river of the Northwest is the Columbia. From its fountainhead in the Rocky Mountains it flows westward into the Pacific, forming part of the boundary between Washington and Oregon. Its main tributary, the Snake River, has also carved out for hundreds of miles a wonderful canyon. A strange and oppressive gloom clings to this canyon because of the black basaltic rocks of which the cliffs are formed. The upper parts of this system are unnavigable because of the many falls and rapids, but offer for that reason magnificent scenery. The Shoshone Falls are among the most famous in the United States. So many salmon pass up the Columbia to lay their eggs that the catching and canning of these fish has become a leading industry.

On the Columbia River is Grand Coulee Dam, the most massive man-made structure in the world, also Bonneville Dam with its interesting system of fishladders and locks, especially built to permit the salmon to pass by the dam. For pictures and description of these great dams turn to Volume 4, pages 372-373 and 384-386.

The mouth of the Columbia was discovered in 1792 by Captain Gray of Boston, who named the river after his ship. During the administration of President Jefferson, Captains Lewis and Clark, in a wonderful expedition, reached the headwaters of the Missouri, and crossing over to the Columbia, explored that river to the Pacific. This exploit made known to the people of the United States for the first time the great region of the Northwest.

THE GRAND CANYON OF THE COLORADO

One of the most remarkable of rivers is the Colorado, which rises in the mountains of Colorado, Wyoming, and Utah, and flowing for the most part through a high and arid table-land, enters the Pacific through the Gulf of California. Throughout a part of its course it has cut in the solid rock a magnificent canyon which is one of the wonders of the world.

The Grand Canyon of the Colorado River is a most awe-inspiring gorge some ten or more

Courtesy of Canadian National Railways

MONTREAL AND THE ST. LAWRENCE, FROM MT. ROYAL

miles across, nearly three hundred miles long and with a depth of about a mile. Its steep, towering cliffs are sculptured into wonderful shapes and colored to the most beautiful and varied of tints. Enormous ridges extend for miles out from the brink of the chasm, and towers and pinnacles are everywhere. From the depths of the canyon rise wondrous temple-like forms of gorgeous coloring, towering as far above the flowing river as the summit of Mount Washington rises above the sea. The river's work is not done. It is still wearing away rock, and will probably in the next hundred years carve many more designs on the massive rocks that rise along its course in sheer, impassable precipices. The Grand Canyon has been little explored because of the hardships and constant danger accompanying such attempts.

In past ages the waters of the Gulf of California, into which the Colorado River empties, extended much farther inland than they do today. With the great quantity of mud which it carried, the river built a large bar. The water, separated from the gulf by the bar, formed an inland sea. The river cut a new channel through the bar in its journey to the gulf. The water of the inland sea evaporated, leaving a large valley below the level of the ocean. The lowest point in this valley is 278 feet below sea level. In 1905, the river broke through its bank. Before it could be confined within levees, it had poured into the valley enough water to form a lake about fifty miles long and ten to fifteen miles wide, known as Salton Sea.

THE POTOMAC

A river of beautiful scenery and historic interest is the Potomac, which divides the States of Maryland and Virginia and flows into Chesapeake Bay. On its banks is situated the capital of our country, as well as such historic places as Arlington and Mount Vernon.

Of course we cannot even name all the rivers of an immense country like ours. Each state has its rivers, essential both for irrigation and navigation. The more you learn of the rivers, the more you will understand what a fortunate land ours is in the water distribution. And wherever you find a river, there you will be likely to find prosperous towns and cities and rich farming communities.

A NATURAL BOUNDARY BETWEEN TWO CANADIAN PROVINCES

The stream on the British Columbia side finds its way into the Pacific Ocean. That on the Alberta side finally reaches Hudson Bay.

RIVERS AND OCEANS

A study of the map with regard to the distribution of rivers over the surface of the earth shows that many more watercourses flow into the Atlantic than into the Pacific. The latter ocean, the greatest of all, receives directly only five considerable rivers — the Cambodin, the Yangtze, the Hwang-ho, the Amoor, and the Columbia. The Atlantic, on the other hand, is the reservoir into which the most enormous rivers pour their waters — the Amazon, the Orinoco, the Mississippi, the Nile by way of the Mediterranean, the St. Lawrence, the Congo, the Niger, and all the watercourses of western Europe, as well as many others.

MOUNTAINS THE MOTHERS OF RIVERS

In general the great watercourses have their source in lofty and massive heights. Our Mississippi gathers in her capacious arms springs and runlets, cascading brooks and quiet streams, from the eastern flanks of the Rocky Mountains to the Blue Ridge, beckoning them along devious yet ever converging paths down to her delta. In Europe the snowfields and glaciers of the clustered Alps form a reservoir whence rivers radiate in all directions — the Rhine to the North Sea, the Oder and Warthe to the Baltic, the Danube, Save, and Drave to the Black Sea, the Rhone and the Po to the Mediterranean. But the combined amount of water flowing away from the Alps, the Pyrenees, and the Carpathians is small compared with the supplies yielded by that huge elevation in Central Asia, well called "the roof of the world," whence a round dozen of rivers, each more than a thousand miles long.

GREAT DIVIDES

An elevation which separates one watercourse from another, or sends the rainfall on one side into one river system and on the other slope into another system, we call a "divide." Each

continent has one or more "great" or "continental" divides, which separate all the waters flowing into one ocean from those draining away to another. There are three in North America: the Rocky Mountains, west of which all the waters go to the Pacific, and east of which all the drainage is into the Gulf of Mexico; the low "height of land," which runs irregularly from southern British Columbia to the vicinity of Lake Superior and thence east to Labrador, dividing the rivers flowing to the Arctic Ocean and Hudson Bay from the tributaries of the Missouri and the St. Lawrence; and the Blue Ridge and its extension northeastward, the Gaspé, which separate the Ohio and St. Lawrence valleys from the Atlantic slope. Along the crests of these three divides originate all the rivers of importance; and a similar classification of systems may easily be made for the Old World by a study of the map of the Eastern Hemisphere.

GREAT CITIES AND GREAT RIVERS

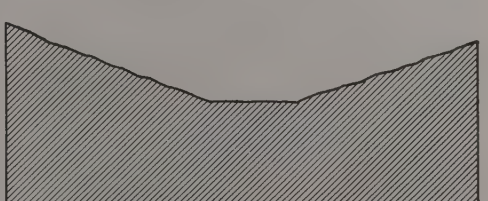
It is an old query: "Why do big rivers always flow by big cities?"

Anyone may see through and laugh at the topsy-turvy logic; and anyone by a moment's thought may understand how it is that, as a matter of fact, important cities have nearly always grown on the banks of large rivers or at their mouths. It would be hard to find an exception to this, apart from towns, like Denver, Winnipeg, Calgary, Manchester, Johannesburg, and some Russian cities, which have sprung into life since railroads furnished sufficient transportation for the needs of interior districts. The great towns of ancient days — Nineveh, Babylon, the Chinese, Japanese, and East Indian cities, Tyre, Sidon, Byzantium (Constantinople), Rome and Carthage — were each on a navigable river or beside the sea, — usually both. It was so in medieval Europe, and the principal reason for it was the same as in the ancient East, namely, that almost all ancient travel and trade was by water.

When you have a load to carry across country you seek a level path and avoid hills, you take advantage of every slope and valley that lead in your direction, and where a river is handy you construct some sort of boat and utilize that. Thus, in a primitive time or region, wherever a river with its branches offers navigable waters, travelers and traders, producers and merchants will naturally gather in its valleys. Much commerce has always been sea-borne, and the sailors and merchants engaged in it have always found it most profitable to carry their goods as far by water as possible, for transshipment is expensive and slow; hence they seek the innermost parts of bays and harbors, and ascend rivers as far as they can, before landing their cargoes. Thus the inlanders coming down the river valleys, and the sea traders sailing up them, meet most conveniently, and therefore most numerously, at the head of navigation, which, in old days, remember, was higher upstream in many cases than now, because the ships in use then were much smaller.

So it has naturally come about that popula-

SECTION OF A YOUNG RIVER VALLEY



SECTION OF AN OLD RIVER VALLEY

River valleys may be young, middle-aged, or old. The diagram at the left shows a young river valley. A young river has steep-sided banks and valley sides. As it grows older it wears down its sides. The Grand Canyon of the Colorado is a valley of this type. In the diagram at the right the river valley has grown older. It has had time to wear down its sides. It may take a river thousands of years to grow old. Usually rivers grow old much more slowly in deserts than in regions of great rainfall.

tion everywhere is most dense along the watercourses (the superior fertility of valleys must also be considered), and that the great cities have grown almost invariably where river and sea navigation meet. Think of the many examples — London, Paris, New York, Philadelphia, Amsterdam, Buenos Ayres, Montreal, Hankow-Wuchang, Calcutta, and many others — which fit that situation and history. Even the modernization of methods of transportation has made no serious change, for heavy freight is still carried most economically by water, and all railroads seek the lowest and easiest routes to the ports — water grades, as engineers call them.

What but its situation has enabled New York to become the second largest city in the world? From New England by the East River, from northern New York and Canada by the Hudson, from the West by the Erie Canal along the Mohawk and then down the Hudson, from the Southwest by the Delaware, Raritan, and Passaic valleys, all the easy roads by either land or water lead to the American metropolis and its incomparable harbor. Hence it *is* the metropolis!

Similar conditions have built up Philadelphia, Boston, Baltimore, Pittsburgh, St. Louis, New Orleans, San Francisco, and the towns on the shores of the Great Lakes.

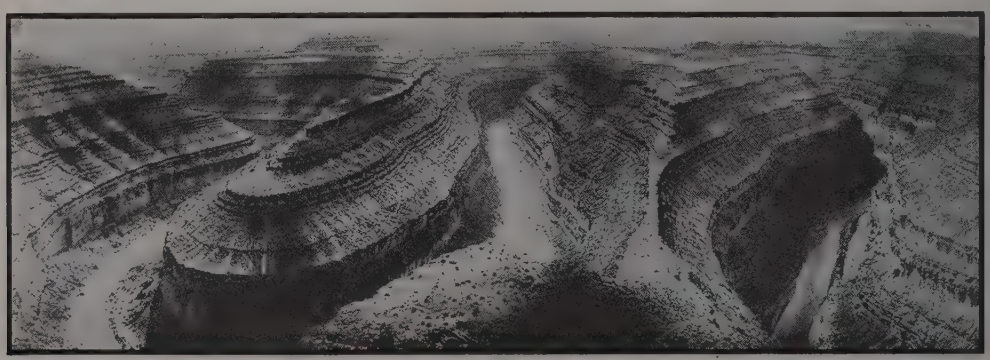
RIVER VALLEYS AND DELTAS

A river is constantly producing two kinds of changes in the earth's surface. It is always wearing away certain regions. With the materials which it transports from these regions it builds land in other places. When a river flows swiftly it erodes, that is, wears away, the land rapidly, and the valley which it forms has steep sides. The river occupies a rather narrow bed in the bottom of the valley.

When the slope of the river bed becomes less steep the stream erodes less rapidly. The valley widens as a result of the washing of its sides by rains. Because of its gentler flow the river tends to be more easily turned aside by slight obstructions. This causes it to wind, or meander, through its plain.

Some of the coarser materials which the stream is transporting are deposited when the rate of flow becomes less. If the river overflows its banks it leaves some of its finer materials on the plain. It has begun the work of building, but it carries a large portion of the finer material onward to its mouth. If it enters a quiet body of water, it deposits much material with which it constructs a continually enlarging delta. As the delta grows, the stream cuts new channels through it and deposits new loads at the ends of these channels.

In this way large rivers build well-watered areas of fertile soil several hundred square miles in extent. The Mississippi has built a delta two hundred miles long with an area over twelve thousand square miles. It has been estimated that the Mississippi has been pushing forward into the Gulf of Mexico at the rate of a mile in sixteen years.



Courtesy of U. S. Geological Survey

SHOWING THE MEANDERS OF THE SAN JUAN RIVER, UTAH

THE WATERWAYS OF THE WORLD

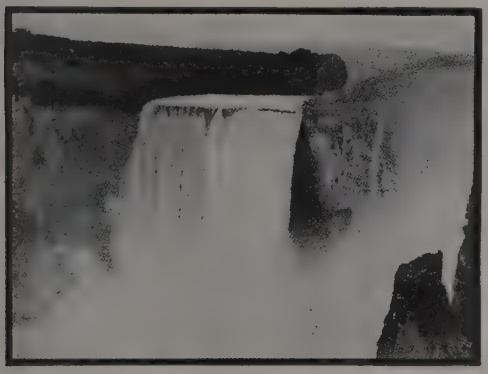
These relief maps of continents enable one to trace the great river courses of the world. This comprehensive glance shows the remarkably even distribution of water, and its absence in the desert belt. (Three lower maps used by permission of Ginn & Co. Copyright, 1912, by A. E. Frye.)

Courtesy of Transcontinental & Western Air, Inc.

LOOKING INTO THE GRAND CANYON OF THE COLORADO RIVER

WATERFALLS AND RAPIDS

AS a river works its way from the mountains to the sea, it passes over many kinds of rock and soil. Even in a single spot there will be layers of soft and hard rock, laid one upon another like planks in a lumber pile. As the water flows over these rocks, it will wear down the soft more swiftly than the hard and will even carry off some of the layers, leaving the others rising from the river bed in sharp cliffs.



KAIETEUR FALLS, BRITISH GUIANA

The river bottom at the foot of such a cliff will be quickly worn away by the force of water falling from the height, and the head of a waterfall will be formed. When the water drops straight down, we call it a waterfall or cataract; when it tumbles over rocks which are not high enough to make a long drop and yet break its even course, we say it makes rapids. Some of the world's waterfalls have been worn away within the time that man has lived on the earth; but the more magnificent ones were probably caused, not by running water, but by moving ice which in the Glacial Age covered the world.

WHAT CAUSES WATERFALLS?

After the ice was gone, the rivers had to form new courses. In most cases this probably meant the making of new rivers. The ice had scooped the land out in some places while in others it left great piles of rocks and débris piled about. Sometimes this material was piled in great hills. The rivers and other streams have not had time since the last ice age to wear out great valleys. They are still tumbling about in their new courses. As a result we have waterfalls. Give the rivers several millions of years and the waterfalls will disappear.

Waterfalls are sometimes found in and near mountains, where mountain streams plunge into the valleys below. Such sections are sometimes called Piedmont. The word *Piedmont* means "at the foot of the mountains." Water power can easily be secured in such an area. Some of the great industrial areas are found near waterfalls.

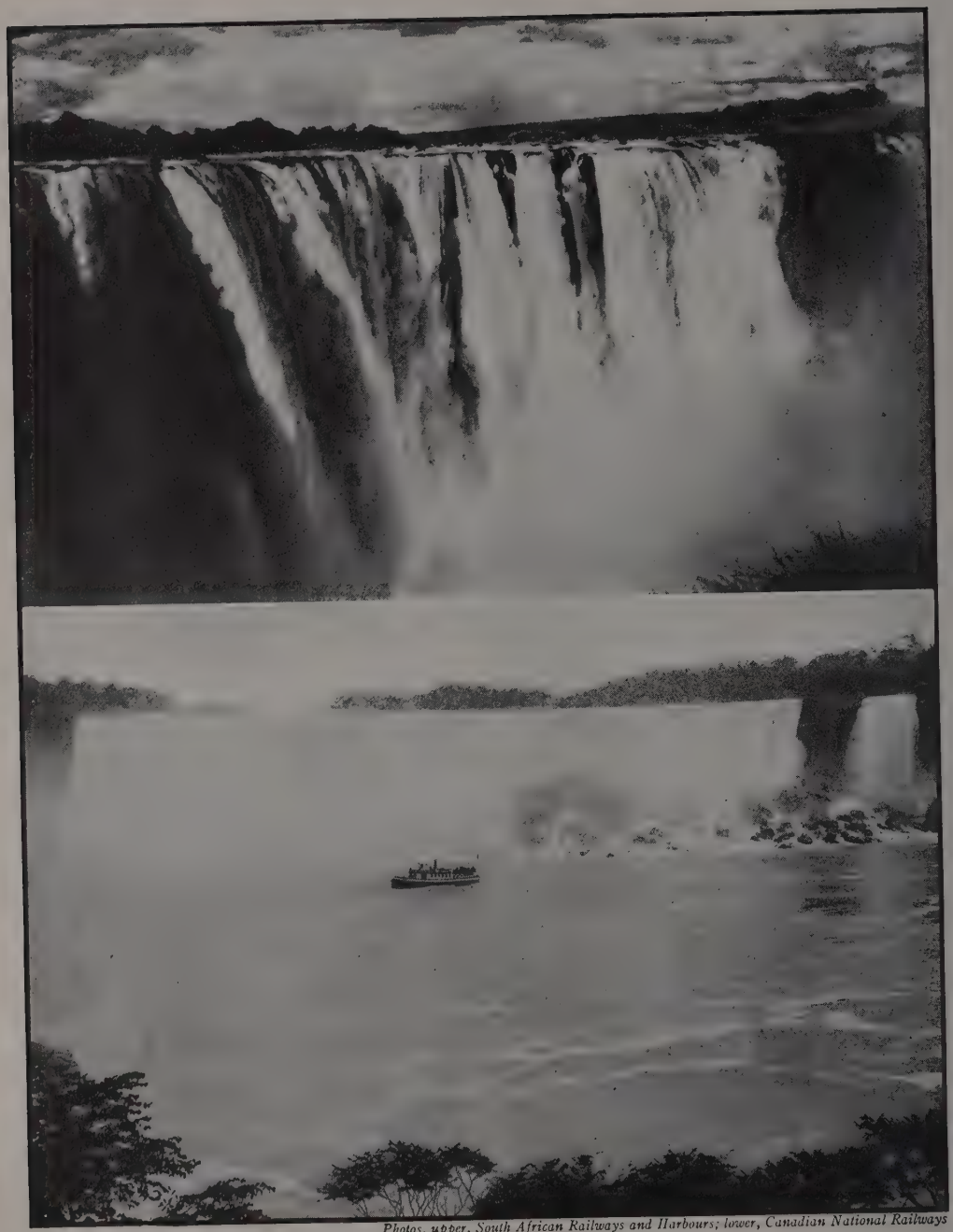
NIAGARA

Niagara Falls is our most wonderful waterfall. It is only 165 feet high, while Sutherland Falls in New Zealand are 1904 feet high, Ribbon Falls in the Yosemite 1612 feet and Gavarnie Falls in the Pyrenees 1430 feet. However, the amount of water coming over the cliffs of Niagara is so great that it is thought to surpass the higher falls in grandeur. Long before the white man saw these falls the Indians looked on them with awe and dread, and gave them the beautiful Iroquois name, Niagara, the "Thunder of Waters."

The first white man known to have seen Niagara was the famous explorer, Father Hennepin, who was a member of La Salle's party in 1678. He wrote in the quaint language of the time that "the Waters which fall from this horrible precipice do foam and boyl after the most hideous manner imaginable, making an outrageous Noise, more terrible than that of Thunder."

More than a hundred years later another famous Frenchman gazed upon Niagara, and left a description that is well worth repeating. Said Chateaubriand, the brilliant friend of the heroes of our Revolution:

"From Lake Erie to the falls the river bed descends very rapidly, and at the point where the waters take their leap, it is less a river than an ocean whose floods hurry into the yawning gulf below. The cataract is divided into two portions, and is curved in the form of a horseshoe. An island juts out between the two falls, which is hollowed out underneath, and hangs suspended with all its trees over the chaos of



Photos, upper, South African Railways and Harbours; lower, Canadian National Railways

ABOVE: VICTORIA FALLS, AFRICA. BELOW: THE AMERICAN FALLS AT NIAGARA.

Courtesy of Canadian National Railways

NIAGARA SEEN FROM THE AIR

Ewing Galloway

NIAGARA IS MARVELOUSLY BEAUTIFUL IN WINTER DRESS OF ICE

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NIAGARA FROM PROSPECT POINT — THE RAPIDS ABOVE THE FALLS

waters. The mass of water which falls in the center rounds out like a great cylinder, and then unrolls in a snowy sheet, which glistens with every color in the sunshine. That on the east side falls into frightful shades, a very deluge of water. A thousand rainbows curve and cross each other over the abyss. The water striking the yielding rock rebounds in whirlwinds of vapor, which rise above the forest like the smoke of a vast conflagration. Tall pines and hickories and phantom-like rocks decorate the scene. Eagles are carried whirling down to the bottom of the gulf, dragged down by the current of air, and lynxes suspend themselves by their long tails to the end of some branch over the abyss in order to seize the mangled remains of the elk and the bear brought down by the waters."

This is a very vivid picture, and while the forest has given way to houses and streets, and eagles and lynxes no longer indulge in such amazing acts, the description of the rushing waters divided by Goat Island remains accurate and striking. Goat Island lies between the American and the Horseshoe Falls, and it seems as though every instant this torrent-swept land would be carried bodily down into the abyss. It resists the tremendous force, however, though every little while a big bowlder is torn away and hurled into the seething depths. On one point of Goat Island is the celebrated Cave of the Winds, a grotto near the foot of the cataract. Here the courageous visitor, wrapped in a veritable whirlwind, may be said to be in the very heart of the falls. In that rocky chamber there is nothing between him and the huge curtain of water, from six to ten yards thick, falling in a deafening roar.

It is of interest to know that Niagara Falls has not always been where it is now. Geologists tell us that perhaps 35,000 years ago it was at the Niagara Escarpment, a great cliff near Queenston. Gradually it has worn its way backward until now it is about seven miles from the escarpment. In centuries to come the cataract may creep right on up to Lake Erie unless it is robbed of all force by being harnessed for electric power. Nearly half a million tons of water leap over Niagara every minute, enough to generate five million horse power. At present one and a half million horse power is generated.

FAMOUS WATERFALLS

The highest succession of falls in the world are those of the Yosemite Valley in California. Two ledges of rock break the flow of water into three falls, the total height of which is over 2000 feet. At the beautiful Staubbach Fall in Switzerland, a narrow ribbon of water makes a sheer drop of nearly 1000 feet and is thrown back in white mist before it reaches the ground, so that the bottom of the fall is always lost in cloud.

There are remarkable cataracts in many places in the world — among them the Schaffhausen Falls on the river Rhine; the Riukan-fos, in Norway, which leaps 885 feet; the Paulo Affonso, in Brazil, which divides into four immense columns and dashes down a gulf 246 feet deep; and the beautiful Bridal Veil Fall, in the Yosemite Valley, which has a sheer drop of 630 feet, and looks like a fluttering silver scarf with rainbows interwoven.

The Victoria Falls in South Africa are much larger than Niagara, being 1860 feet wide to Niagara's 1000 feet, and very nearly twice as high. They were discovered by David Livingstone in November, 1855, and named by him for Victoria, then queen of England. Sometime you will read the story of his explorations in Africa, and get a little feeling of what it would mean to come upon such a wonderful sight as these falls, and know that you were the very first white man who had ever seen it. Think of taking back to the world the story of such a nature wonder as this, of which no one had ever heard before!

WATERFALLS IN THE UNITED STATES

While the grandeur of Niagara is not elsewhere equaled in the United States, there are, nevertheless, many very beautiful falls that afford evidence of Nature's generosity. Just east of the Rockies the Missouri River forms quite a series of rapids and falls, among which the best known are doubtless those at the point where the city of Great Falls is located.

Idaho is particularly fortunate in the scenic beauty of the falls made by the Snake River, where it crosses the southern portion of the state. Here it cuts deeply into the crust of lava spread over that region, and so varies its course

Ewing Galloway

BRIDAL VEIL FALL, YOSEMITE VALLEY, CALIFORNIA

by rapids and waterfalls. Famous among these are Twin Falls and Shoshone Falls. Just below the latter a short canyon of the Snake River opens into the greater canyon and heads in a natural amphitheater three hundred feet in depth. This chasm receives no water from the surrounding plains, but is fed abundantly by subterranean streams that find outlet in great springs in the bottom of the valley.

Another western state that claims a beautiful waterfall is Oregon. Multnomah Falls is on the south bank of the Columbia River just below the Cascades. There a small tributary of the Columbia drops eight hundred and fifty feet over a sharp precipice and forms a shining ribbon of water as it falls.

UNDERGROUND RIVERS AND CAVES

SINCE the days when the first men who lived on the earth, exploring their surroundings, found in the rocks chambers and caverns ready hollowed out for their homes, caves have had a great fascination for mankind. There is a strange mystery about them. To go underground into a series of winding passages not made with hands, leaving behind the familiar world of sunshine and everyday activity, is to experience a mysterious awe and dread which will continue as long as human nature loves light and color and avoids darkness.

The real story of caves is as wonderful and absorbing as any fairy tale. Most of these rugged chambers are carved out of rock by underground water. In its journey through the earth the water gathers up quantities of carbon dioxide which comes from the decay of animal and vegetable matter. Dead leaves and fallen branches of trees furnish a great deal of this substance. So the water takes it on its travels, and combines with it to form carbonic acid. Carbonic acid can dissolve certain substances in the rocks which do not dissolve in water. Limestone is dissolved especially easily by the carbonic acid in the water. The most remarkable caves in the world are in limestone regions.

THE WORK OF UNDERGROUND WATER

After a while these underground rivers change their courses or vanish, leaving behind the record of their work. Sometimes a whole gallery of caves has been worn away in the solid rock. But such a process takes countless ages, and is never finished. Water trickles into the ground above the cave roof, and passing through the porous limestone carries with it a tiny particle of a chemical called carbonate of lime. Drop after drop of the water leaves behind it on the cave roof a bit of whitish substance, which is the larger part of the lime it held. This is the beginning of a stalactite. If stalactite is a word that has no meaning for you, imagine an icicle of white stone slowly growing downward, grain by grain, until it reaches the size of a tree trunk! The drops of water also deposit a mite of lime on the floor of the cavern, and little by little they build a stalagmite, which grows up to meet the stalactite. Perhaps hundreds of these are being formed at the same time in a vast cave. There are few sights in the world more amazing than one of these underground galleries filled with dead-white columns and groups of immense stony needles. The pictures will show you the difference between stalactites and stalagmites.

The water sometimes contains other minerals besides limestone. These minerals produce the lovely streaks of color which are found on the stalactites and stalagmites of some caves.

FAMOUS CAVES

The Adelsberg caves in the Alps are famous for their stalactites, and also for the torrent that roars through the principal cavern there. But this whole district, which extends to the east of the Adriatic between Laibach and Fiume, is the most remarkable in Europe for caves, underground streams, and abysses. The whole surface of the country is pierced with deep, boat-shaped cavities, at the bottom of which water may be seen in a kind of whirlpool. Many mountains here are fairly honeycombed with caverns and passages. The most curious part of the Adelsberg labyrinth is that which appears to have been the former bed of the Poik River. It affords wonderful groups of stalactites, especially in the "Salle du Calvaire," which has a vaulted roof of two hundred and ten yards' span that has let down a forest of ghostly columns.

Underwood & Underwood

GIANTS' HALL, LURAY CAVERNS, VIRGINIA

Showing the marvelous formation of stalactites and stalagmites.

Many extremely interesting remains of the "cave man" and long extinct animals have been found in the grottoes of Europe, England, Australia, and America. They throw light upon the early history of man and the changes brought about in animal life and climate. One of the earliest caves to be examined in a scientific way was that of Gailenruth in Franconia, Germany. Beneath the stalagmite floor were found immense quantities of animal remains, including the bones and teeth of the lion, hyena, grizzly bear, mammoth, and reindeer, all of which had long ceased to exist in that region. In the celebrated cave at Wookey Hole in the Mendip Hills, England, signs of the presence of man were found. These consisted of an oval implement of flint, very roughly made, a short arrowhead, and some fragments of chipped flint, together with two bone arrowheads. Then better utensils of early man's making came to light in other caves, showing the progress of his civilization; and in caves of Spain have been unearthed wall paintings of animals done in rude colors.

THE MAMMOTH CAVE

The famous Mammoth Cave in Kentucky might be called a subterranean world, having a system of lakes and rivers, and a network of galleries and passages without number, which cross and recross one another, going down to an immense depth. There are some two hundred miles of alleys, the actual length of the cave being estimated at one hundred and fifty miles. The average height and width of the passages are reckoned at seven feet. No less than twelve million cubic yards of material have been gradually excavated by the slow wearing of carbonic-acid-laden water through the rock. The cave once served as a retreat for savage tribes, for skeletons of an unknown race have been found buried in it under layers of lime.

Of the highest interest are the strange creatures that at present live in the Mammoth Cave. First among these is a curious small fish, about five inches long. It is white, but its most striking peculiarity is its complete blindness, which is attributed to its having been cut off from the light of day for generations. To make up for this loss, the little fish has extraordinary powers of hearing and feeling. It is difficult to catch and very rapid in movement. A small blind crayfish also inhabits this cave, and there are wingless grasshoppers, and two queer, sightless species of beetle. Both in the Mammoth and Adelsberg caves small eyeless spiders have been

THE BLUE GROTTO, AT CAPRI, THE SOUTHERN ENTRANCE TO THE BAY OF NAPLES, ITALY

A BRIDGE BUILT BY NATURE

Natural bridge known to the Indians as Nonnezoshi (the stone arch), the largest natural arch yet found, measuring 308 feet in height and 275 feet between the abutments. It spans the canyon which extends from the slopes of Navajo Mountain northwest and joins the Colorado River.

caught. All of the creatures found living in caves are usually colorless, weird specimens. This excludes naturally all those birds and beasts, like owls and foxes, that simply hide and sleep in such places or drag their victims there.

Carlsbad Caverns in New Mexico have in recent years attracted attention because of their beauty and size. Recently an exploring party spent some time in surveying these caverns. They found great holes and abysses. It took them weeks to complete their explorations. The caverns are many miles long.

Sea-hewn caves must not be forgotten, as some of them are very remarkable. Nearly all of us have seen gigantic waves break upon a rockbound coast and tear away at the stone. The fury of Atlantic storms has carved out the beautiful cave on the Island of Staffa, Scotland, which in ancient days was supposed to be the work of Fingal, the demigod, and it bears his name. Among the Orkney and Shetland Islands there are magnificent examples of the architecture of the sea in the shape of underground tunnels, caves cut inland for considerable distances.

THE CAVES OF OCEAN

Caves may be due to volcanic action, or to the violence of an earthquake. But the most familiar are those eaten out by the slow, gentle action of water. Perhaps the best examples of caves thus produced are the hollows and excavations so often seen at the base of inland cliffs. Sometimes these are merely the result of century-long wear of frost, rain, and heat. The stupendous effects of such prolonged weather

NATURAL BRIDGE, NAHANT, ON THE MASSACHUSETTS COAST

DeCou-Galloway

THE GREAT GLACIER AT GLACIER, BRITISH COLUMBIA

action alone are best seen in the rock shelters of the cliffs of New Mexico and Colorado, where the mysterious cliff dwellers made their homes, like eagles, in the face of forbidding walls of stone, which appear to be unscalable.

NATURAL BRIDGES

In many parts of the world are natural bridges of rock which are a puzzle to geologists. Some appear to have been formed by the falling in of the roofs of old caverns. Others connect two sides of a narrow valley where a cavern may never have existed.

GLACIERS, RIVERS OF ICE

GLACIERS have already been described as rivers of ice moving down gorges from high mountains, whose peaks are perpetually covered with deep blankets of dazzling snow. The changing of snow into bluish, transparent ice is one of Nature's magical processes. First the falling flakes pile up in high snow banks on the mountain tops during the winter; then at the touch of spring sunshine they begin to melt and cling together, and the closer they cling the firmer and more solid are the snow masses. Any child making a snowball knows how this is done. Press the snow together and it will become solid and hard. It is now ice which is composed of crystals packed tightly together. On a mountain slope the pressure of hundreds of tons of snow forms ice which is almost as hard as rock. The increased weight tells the fact in striking figures: A cubic yard of snow weighs on the average one hundred and eighty-seven pounds, while a cubic yard of glacier ice weighs over ten times as much. It is easy to see that, with such weight, if the mass once begins to move, nothing can resist it.

Slowly, very slowly, the ice moves downward

Courtesy of Travel

AMONG THE DOLOMITES

These snow-capped mountains of the Tirol are streaked with vivid colors. They take their name from the mineral of which they are formed.

and gets entangled in mountain gorges or fills up whole valleys. Some of these glaciers — those of the Pyrenees, for instance — extend only over the upper slopes of the mountain, and do not descend through the gorges as far as the cultivated land at its base. These are known as secondary or summit glaciers.

Other fields of ice flow out into the mountain amphitheaters and make their way into the lower valleys, and these are glaciers of the first order.

On its course the solid river behaves as would a real river of running water. It has its meanderings, its eddies, its depths and shallows, its rapids and its cascades. Like the water, which expands or contracts according to the form of its bed, the ice adapts itself to the dimensions of the ravine containing it. The ice stream is continually molding itself upon the rock, as well in the vast basin whose walls widen out on either side as in the defile where the passage almost closes up. But the ice, lacking the fluidity of water, has to accomplish all the movements forced upon it by the nature of the ground in an awkward though picturesque manner. It cannot, at its cataracts, fall in one level sheet as does the water current; but, according to the irregularities of the bottom and the condition of its ice crystals, it cracks, splits, gets cut up into blocks which lean in every direction only to fall over one another like clumsy clowns, and become cemented together again in funny obelisks, towers, and fantastic groups.

HOW FAST DO ICE RIVERS MOVE?

Alpine mountaineers knew for ages that glaciers moved onward, conveying masses of rock from the mountain tops to the valleys, but the fact was not known to scientific men until the end of the sixteenth century. No one actually tried to prove it until a seeker after knowledge, named Hugi, built a little hut on the glacier Unteraar, in 1827. Three years later the hut had moved down 330 feet; at the end of six years it had traveled 2340 feet; and by 1841 it had reached a distance of 4683 feet from its first position, or the best part of a mile. Professor Tyndall spent much time studying the glaciers of Switzerland, and he observed that their most rapid movement was thirty-seven inches a day. But there were also places where the motion was not more than two inches a day. Up in Alaska there is an immense ice river, the Muir Glacier, flowing at its narrow outlet at the rate of about seventy feet a day, and falling *into the sea.* Really feeding the ocean with icebergs! Dr. G. F. Wright describes it in the following vivid passage:

"There is a constant succession of falls of ice into the water, accompanied by loud reports. Scarcely ten minutes, either night or day,

passed without our being startled with such reports; and frequently they were like thunderclaps or the booming of cannon at the bombardment of a besieged city, and this though our camp was two and one-half miles below the ice front. . . . Repeatedly I have seen vast columns of ice extending up to the full height of the front topple over and fall into the water. How far these columns extended below the water could not be told accurately, but I have seen bergs floating away which were certainly five hundred feet in length," or as high as the Washington Monument.

By driving rows of pegs across glaciers and observing them from time to time, investigators have found that these great masses of ice move more rapidly near the center than at the sides. The upper portions move more rapidly than the lower parts.

WHY ICE RIVERS MOVE

The causes of the motions of glaciers have been subjects of investigation for many years. Of course, the main cause is the weight of the ice mass, but this would not produce motion if it were not for certain characteristics of the ice itself. Several suggestions have been offered to explain just how the nature of the ice helps to give the glacier motion. The explanation which at present seems most probable depends partly upon the fact that when the ice crystals are lying in a certain position one part of each crystal can be pushed over another part, causing a slight slipping of the ice.

The second important fact is that under great pressure, ice melts at a lower temperature than the usual one. Because of the tremendous pressure in a glacier, ice is continually being melted. At the points where the melting occurs, the upper layers of ice are free to move over the lower ones. This motion relieves the pressure, and the water freezes again. Once more the pressure increases, and the whole process is repeated.

In the surface of the glacier occur many cracks, or crevasses, which vary in size from a few inches to many feet. In a number of ways they are the most interesting features of a glacier. One common cause of these crevasses is the unevenness of the ground over which the glacier is moving. Even a slight slope causes the surface to crack. The steeper the slope, the wider are the crevasses.

Often they reach a tremendous width and depth. Sometimes they are hidden under banks of snow, and it is then dangerous to travel over the ice river. But suppose we are looking down into one of the cold chasms, what do we see? Layer upon layer of bluish ice separated by black bands, which mark the remains of débris fallen upon the once snowy surfaces. At another time and place the crevasse walls will appear perfectly clear. We wonder what is the depth of the chasm, but cannot guess, for a short distance down the darkness becomes impenetrable. We may hear a mysterious noise from the abyss. What is it? The roaring of a buried stream, perhaps, reverberating in the echoing walls of ice, or the crash of a stone falling hundreds of feet. Explorers have been let down by ropes into these chasms to measure their density and to study the temperature and composition of deep ice. These experiments, like all glacier study, are attended with great danger, since the ice may shift at any moment and crush a man between its blocks. Many a mountaineer has met his death crossing these changing ice chasms.

The Alps have the most famous glaciers, like the Mer de Glace and the Rhone and the Great Aletsch glaciers; but there are as wonderful and extensive ice rivers in Scandinavia, in Greenland, and in Alaska. They serve to remind us of the Glacial Age, when the greater part of our North American continent was covered by a huge sheet of ice, which was polishing our mountains and valleys into shape. The Niagara gorge was made by ice action.

THE WORK OF GLACIERS

Ice is continually melting at the lower end of a glacier as it advances into places of higher temperature. For this reason, a stream flows from beneath the glacier and continues through the valley beyond. It is usually milky in color because of the quantities of tiny rock particles which it contains.

A glacier resembles a river in the work which it does. That is, it removes material from one region, transports it, and deposits it in some other place. Soil and rocky material from mountain slopes descend upon the edges of a

Courtesy of National Geographic Magazine

A GIANT CREVASSE, ONE PERIL OF MOUNTAIN CLIMBERS

Sometimes crevasses are hidden under banks of snow, making it very dangerous to travel over glaciers.

glacier just as they descend into the stream of a river valley. Sometimes they fall into crevasses and are carried onward inside the glacier. The glacier also wears away, or erodes, the sides of its valley and carries these materials with it.

Rocks, pebbles, and sand are frozen solidly into the bottom of the glacier. As the great mass of ice moves forward, these hard substances are dragged over the rocks in the earth below, leaving them scratched with parallel lines and grooves. Such parallel scratches on rocks in any part of the country are one evidence that glaciers have existed in that region at some time in the past.

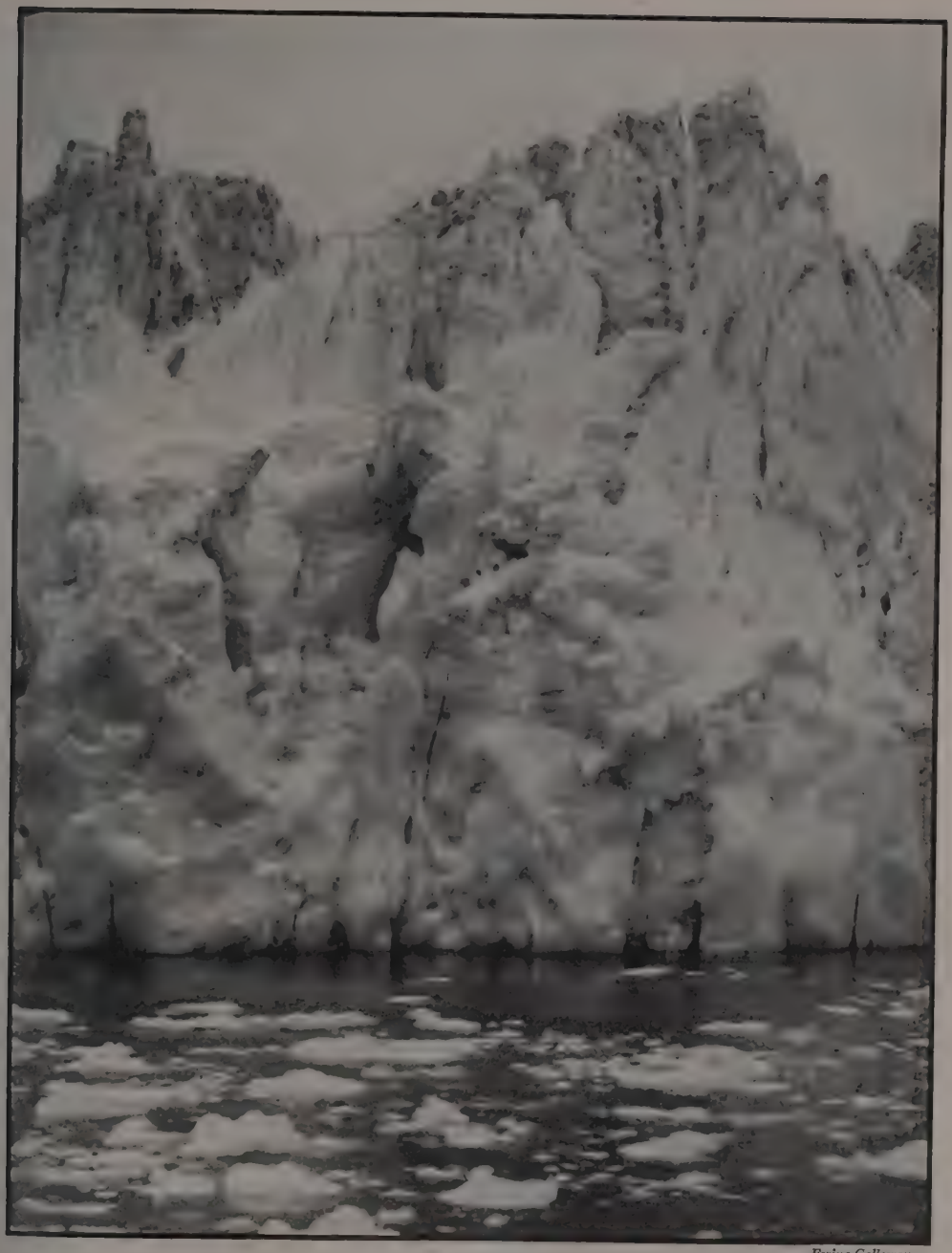
Another evidence of the former presence of glaciers consists in the heaps of earth and stones which have been left by its melting. Sometimes these tumbled heaps are high enough to form low hills. They are composed of the soil and rocks which the glacier transported, often for many miles.

CONTINENTS COVERED WITH ICE

At one time several thousand years ago, northern North America and Europe were covered by a sheet of ice. To-day some of the Ice Sheet still remains in Greenland, where it is 8500 feet thick. The Antarctic Continent, recently explored by Byrd, is covered also by an Ice Sheet 9000 feet thick. Icebergs are great blocks of ice that come from glaciers.

VIOLENT FORCES OF NATURE

WE human beings are the most adaptable of all Nature's children. Most plants and animals have their special regions where the conditions are exactly right for their life, and they die if they are put down in surroundings which are radically different. But there are very few places on the globe where men have not lived. They go to the arctic regions and to the hottest



Ewing Galloway

TAKU GLACIER, ALASKA

It is from glaciers like this, reaching to the sea, that icebergs are born.

desert places, and manage to survive the trying conditions which they meet there. But this is because of the balance of forces which Nature keeps. Let one of these forces get a little out of the usual bounds and break the routine to which

Courtesy of National Geographic Magazine

ICE SLOPE ON A MOUNTAINSIDE

we are accustomed, and suffering and death follow, as when we have avalanches, tornadoes or earthquakes, terrible droughts or floods.

When we talk of these happenings as breaks in Nature's routine, we do not mean that Nature's laws are broken. Each follows some one of these laws. When you slip on the ice and break your leg, you say you have had an accident. But science would say that you failed to keep the balance required for walking, and so gravitation, which is always pulling everything towards the earth, pulled you down. People used to call the unusual Nature happenings accidents, and so they are from the human point of view. But within recent years we have come to believe that there are no accidents in Nature's kingdom. It is not that her laws are being broken, but that the beautiful balance of forces which she usually maintains is being disturbed.

WHY DO WE HAVE AVALANCHES?

Do you remember the fable in which the sun and the wind disputed as to which was the stronger? They set for themselves as a test that each should try to make a traveler take off his coat. Wind tried first. He blew and blew, but the man only wrapped his cloak closer about him. Sun's turn came next. He sent his hot rays down, and in a very few moments the man threw off his cloak and tossed it over his arm. Sun and wind were then working against each other, but often they work together, and when they do they accomplish wonders.

Up in the great snowfields on the mountains, where the snow falls for weeks in the winter, sun and wind are always at work. In Alpine regions the Swiss mountaineers have a proverb that the south wind "eats up the snow." In all seasons, even in the coldest period of the winter, masses of snow, carried away by their own weight, roll from the summits and slopes; these avalanches, however, are merely composed of surface snow, and their effect is trifling.

Many more avalanches would descend on the peaceful mountain valleys if it were not for the sun and the wind. When spring comes in the mountains, the melting begins. Torrents pour down the mountainside, and pools imprisoned under masses of snow and ice escape to join rill or brook. In every ravine, every depression of the ground, this hidden work goes on. But the sun and the wind cannot eat up all the snow, and the tunneling work of flowing water often weakens the upper surface and makes it more likely to slip. Then huge masses of snow slip from the heights and cast themselves into the valleys, burying houses and villages in their headlong rush. Standing at a distance and watching one of these avalanches on a neighboring mountain, one sees an enormous bed of snow plunge forward like a cataract, and lose itself in the lower stages of the mountain.

Whirlwinds of powdered snow, like a cloud of bright smoke, rise far and wide into the air. Then when the snow cloud has passed away and the whole region is again calm, the thunder of the avalanche is heard resounding far below through the gorges. When a field of snow does loosen anchorage, the mass moves with terrific force, carrying before it the trunks of trees, stones, and even huge blocks of rock.

BURIED FOUR DAYS IN SNOW

What the fire-damp is to the miner an avalanche is to the mountaineer. It threatens his home, his barns, his cattle, and it may swallow him up also. Many lives have been lost in these snowslides, but there have been many thrilling escapes. One such story from Switzerland is worth telling. On a spring night a sloping bed of snow, higher than the tallest fir trees and the village tower, fell down, burying a group of cottages and barns. Rescuers hurried to the spot, fearing that their friends had been crushed or smothered. Still they set to work bravely at digging through the snowy blanket. Four days and four nights they labored, and finally they heard voices singing. They found that by great good fortune the houses had withstood the shock and weight of the avalanche, and the air which they contained had been enough for the long wait. While locked beneath the snow the people had managed to dig tunnels from one house to another, and kept on singing to cheer themselves.

TREES FOR A DEFENSE

Two sorts of avalanches are distinguished in the Alps: those known as *paudreuses*, or "powdery" avalanches, and those called *avalanches de fond*, or "of the bottom." The former is a combination of freshly fallen snow and whirlwinds, which sweep down the mountain side with terrible violence, and are much dreaded; the latter are sliding fields, slower in movement, and not so much feared. Thickly planted trunks of trees are the best defense against avalanches, because the snow which has fallen in the wood itself cannot shift its position, and affords a barrier; and when the masses from the bare slopes hurl themselves against the trees, they are usually unable to break through these strong sentinels. A number of villages possess no other means of defense against the snow. We can easily understand with what respect and veneration the villagers regard their protecting woods. Woe to him who touches a forest trunk with his ax! "He who kills the sacred tree kills the mountaineer," says one of their proverbs.

The inhabitants of some villages in the path of avalanches, where trees are not sufficient, try to find a substitute in long stakes or piles driven into the ground to resemble fir trees. This is what they call "nailing up the avalanche." Again, they hew giant steps at given intervals, making a kind of staircase, so that the snow falling from the cliffs may be broken up or partially arrested in its sweep. Walls, too, are built, and new woods cultivated. In these ways man has largely overcome this enemy.

TORNADOES, HURRICANES AND TYPHOONS

Wind is a beneficial nature force when it is quiet and well-mannered. But when wind

International News Photo

A TORNADO

blows with violence and begins to run riot across the face of the earth, there is trouble for all living creatures. In "The Earth a Storybook" we have seen that winds are caused by difference in the temperature and therefore in the weight of air. Tornadoes and whirlwinds are great eddies made by winds blowing from all directions towards a place of low air pressure. These winds as they blow in towards this center get caught in a mad whirl, and spin round and round like a top, keeping this movement as they travel across the country.

Many regions are visited by destructive winds which spin like a top, and gathering up dust or water, look like gigantic funnels. Over the country or ocean they race in a mad spiral, uprooting forests, wrecking houses and ships, and leaving death and ruin in their wake. These terrific winds are known by various names, such as hurricane, typhoon, and tornado. Tropical lands are their favorite haunt, and some paths of the sea are noted for their visits. A tiny revolving tornado may be seen on almost any hot summer day, when little columns of dust, only a few inches wide and a yard or so in height, run spinning along the road in harmless riot.

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TORNADO WRECK AT SOUTH OMAHA, NEBRASKA

A WESTERN TORNADO

Magnify this motion a millionfold and you can imagine what one of our western tornadoes must be. Ferrel, in his fine book on the subject of the winds, describes a tornado that occurred very suddenly at St. Cloud and Sauk Rapids, Minnesota: "The tornado struck the Mississippi River at a point opposite to the village of Sauk Rapids, and fishermen who were in full view of the crossing say that for a few moments the bed of the river was swept dry; and in proof of this remarkable statement they showed me a marshy spot where no water had been before this event took place. Two spans were torn away from the substantial wagon bridge below the rapids, one span being hurled up the stream and the other down it by the rotary motion of the blast, great blocks of granite being also torn bodily out from the piers. The large flour mill near the bridge was leveled. The depot of the Northern Pacific Railroad was demolished, and the central portion of the village itself was attacked with the greatest violence. Being the county seat, the courthouse was located here, a substantial structure, of which only the vault, six iron safes, and the calaboose were left, the latter turned upside down. A fine new schoolhouse, costing $15,000, was completely swept away. The Episcopal church was so utterly ruined that the sole relic thus far found is a battered communion plate. . . . Stores, hotels, a brewery, and four-fifths of the residences in the village were scattered as rubbish along the hillsides or borne away for miles through the air."

HOW A TORNADO IS MADE

The valley of the Mississippi is peculiarly subject to these violent tornadoes. At certain seasons this river is very much warmer than the surrounding lands. From its surface water vapor is mounting, and this is condensed by the surrounding cold air. Thus a channel of rarefied air hangs at low pressure over the Missis-

IN THE TRAIL OF A TORNADO

sippi Valley, and like the corresponding channels over the ocean currents it becomes a storm track. The same phenomenon may take place in an arid region such as we have in the West. The surface of the earth is heated intensely by the summer sun. Layers of air immediately above the ground are warmed, and so become lighter than the colder layers higher up. Usually the heated layers will rise gradually and the heavier air come down; but once in a while, perhaps on a breathless day, a heavier layer of air may be floating on one that is lighter. The heavier layer descends with a circular rush, and a tornado is born.

TORNADO REGIONS

Tornadoes occur more often in the United States than in any other section of the globe, and the month of May seems to be their favorite period, although they have appeared in April, June, and July. Occasionally one will whirl in winter down in one of the Southern States. The middle west is visited by cyclonic storms of varying intensity every year. Many of these storms have been severe, leaving a wide wake of ruin and death. In some localities, notably Kansas and Oklahoma, tornadoes are so frequent that many families have storm cellars dug into the ground away from their houses. They hastily retire to these dugouts whenever danger threatens.

A hurricane in the West Indies, or a typhoon in the China or Indian Sea, is a similar example of wind forces, though they are generally less violent in character than the western tornado. The latter is lightning-like in velocity, and its speed is the despair of men who measure the blowing of the wind. Tornadoes travel over a narrow path, as a rule, concentrating their power in a funnel, the middle of which is a mighty vacuum that sucks up everything in its way. A tornado seldom affects an area more than about five hundred feet in breadth and some thirty miles in length.

Hurricanes are familiar visitors to the West Indies, the southern parts of the Indian Ocean, the Bay of Bengal, and the China Sea, and each of these regions has its special hurricane season. Thus, of three hundred and sixty-five West

Indian hurricanes on record between the years of 1493 and 1885, two hundred and forty-five occurred in the month of October, when the sun has passed south of the line. In the Indian Ocean, also, storms are most numerous after either the vernal equinox or the great heat of summer. Typhoons in the China Sea arrive with the "changing of the monsoons." Monsoons are winds which blow in one direction for six months at a time, April to October, then change to blow for the remainder of the year in an opposite direction.

THE CYCLONE

Some people speak of tornadoes as cyclones, but cyclones are really much larger whirls of winds, being at times as great as five hundred miles in diameter. Cyclones travel regularly across the United States in a northeasterly direction from the southwestern part of the Mississippi Valley. The winds which accompany their approach to any region may be strong, but they are not usually destructive. They commonly bring rain. The rain storms on the Pacific coast are associated with cyclones which originate over the Pacific Ocean.

JAPANESE TORPEDO BOAT FLUNG ASHORE BY A TYPHOON

While it is not correct to speak of destructive whirlwinds as cyclones, they are often grouped with cyclonic storms because their whirling motion resembles a cyclone on a smaller scale.

One remarkable thing about cyclonic storms should be noticed. Those in the northern hemisphere always whirl contrary to the movement of the hands of a clock, while those in the southern hemisphere whirl in the opposite direction. This observation led to a rule of the sea, which has enabled many a ship to ride in safety beyond the track of an oncoming storm: "Facing the wind, the center or vortex of the storm lies to the right in the northern, to the left in the southern, hemisphere."

HABITS OF CYCLONIC STORMS

Hurricanes and typhoons usually start over the ocean because of the great amount of water vapor which, on condensing, makes heat that warms the air and causes it to rise rapidly. They develop in the tropical zones and pass towards the temperate zones. The path followed by Atlantic hurricanes is usually across the West Indies, along the shore of the southern Atlantic States, and then out to sea. Sometimes they visit the Gulf coast and even the Great Lakes. The typhoons of the Pacific Ocean have several paths, some of which cross the Philippine Islands.

WHIRLWINDS IN THE DESERT

Wind is always at work on the shifting sands of the desert, but when a violent wind arises it is liable to do great damage. It catches up the loose sand and whirls it round, causing choking, blinding dust storms. Sand is blown great distances by these storms. After severe whirlwinds, sand from the Desert of Sahara has been found in central Europe, and on ships far out to sea off the African coast.

DESTRUCTIVE FLOODS

There are some sections of our country in which the rivers are expected to overflow their banks when the spring freshets come. It is strange that people will continue to live where there is frequent danger of having their houses swept away; but they do, just as they live in the path of avalanches and in earthquake and cyclone and swamp-fever regions. Sometimes the floods are of unusual character. The year 1913 will be remembered as one of the most disastrous years for floods, not only in our own

A SAND STORM IN THE DESERT: MEN AND ANIMALS MUST BURY THEIR FACES FOR PROTECTION

country, but in England and France. In time, progress in engineering will probably reduce the peril from flood, and the cities in special danger from this cause will be made as safe as human skill and genius can make them. It was necessary, apparently, that thousands of people should lose their lives, and millions of dollars' worth of property be destroyed, before men would see the folly of living in peril from the elements.

OTHER SUDDEN CHANGES IN NATURE

Natural happenings which are sudden and cannot be predicted are always terrifying. The more we learn of Nature's laws, the more we are able to foresee certain events. Eclipses of the sun and moon ceased to frighten when the time of their appearance could be calculated. But the changes of which we have been speaking, and the changes in the earth's crust, with its accompanying earthquakes, tidal waves, and volcanic eruptions, will always carry danger even when they are better understood. We can take precautions against them. We do not build our houses on volcanoes, and we try to avoid districts where flood and drought are probable. But no amount of understanding ever prepares us for these disasters.

Geologists are able to tell us in which regions earthquakes will probably occur, and it is possible to construct buildings that can withstand all but the most terrible shocks.

But the understanding of causes does not entirely prevent disasters, and man continues to be awed by the forces of nature. He is learning how to prevent some kinds of disasters, such as fires and floods. He is learning to predict other kinds such as volcanic eruptions, earthquakes, and storms. Man is becoming a great engineer and is building houses which can ride the earthquake, building levees and reservoirs to prevent floods, and fireproof buildings which prevent disastrous fires. There may come a time when great disasters will be very rare, although earthquakes, volcanoes, and tornadoes are bound to continue.

U. S. Bureau of Mines

DREDGING FOR GOLD IN CALIFORNIA

BURIED TREASURE

MOTHER Earth buried much of her treasure long ago, and her children have been finding it ever since. There is never a year when inquisitive man does not come upon some form of it and bring it to light. She was not like the pirates of other days, who buried their treasure on desert islands and left no sign of its whereabouts. She made the earth beneath man's feet a great storehouse of many kinds of wealth. On these he might draw as soon as he knew how to make use of them. Upon the surface of the ground were left many signs by which he might locate these precious stores useful to him in the program of civilization.

MINERAL WEALTH

One of the wonders of the world is the vast amount of mineral wealth stored away under our feet. Until we stop to consider, we do not realize how dependent we are on minerals. Think of the numbers of ways in which we make use of them in our daily life. We use metals for tools, for machines, as rails for our railroads and wires for our cables and telegraph and telephone connections. Half the machinery of our modern civilization is made from metals, fashioned by heat and pressure into thousands of forms. The gold supply of the world is hoarded and watched over with the greatest care, for all our system of money exchange depends upon it. The finding of a great gold field may at any time affect the scale of prices all over the world.

Man would have been less comfortable and much slower in his progress in civilization if he had not found in the earth stores of energy in the form of beds of coal, supplies of oil, petroleum, and natural gas, asphalt for his pavements, and peat for his fuel. He could never have built his fine cities or carved his wonderful statues and monuments if he had not discovered beds of granite, marble, sandstone, and other building stones. What a terrible loss it would have been to the world if the Greeks had not had marble with which to put into enduring form their dreams of beauty! The moment when men first worked in stone marked the

beginning of a permanent memorial kept from one century to another.

Besides these more useful substances there are precious stones and gems, diamonds, sapphires, and rubies, the topaz, the emerald, the beryl, the opal, and the garnet, which Mother Earth has tucked away in her veins for her children to come upon with delight.

HOW DO WE GET METALS FROM THE EARTH?

Metals are found in rocks, either free, in their pure state, or combined with other substances. If there is enough of a metal in a rock to make it worth our while to get it out, we call the rock ore—an iron ore, copper ore, or the like. These mineral ores occur either on the surface of the ground, when they can be obtained by simple quarrying, or in veins and deposits at various depths underground, when they must be mined. The story of how mining is done belongs with industries; but it is interesting to know that from the earliest times of which we have any knowledge, some form of mining has been practiced. The Egyptians, the early Britons, and the Romans were all experienced in mining. But the growth of power machinery within the last century has revolutionized the methods of mining. Only since we could work in the rock with the aid of power machinery have we been able to take metals from the ground in large quantities with great speed.

In thinking of our underground wealth we should remember that we who live in the twentieth century are the most favored people who have ever dwelt on the earth. We have the tools and the scientific knowledge to find and make use of more of these hidden riches than

U. S. Bureau of Mines

LOADING ORE IN A MISSOURI LEAD MINE

any earlier generation. New stores of wealth are also being opened up in our day. The Chinese have always feared any attempt at mining, because they believed that a powerful dragon lived underground who would be angry if he were disturbed. Now the great natural resources of China are being developed.

IRON, THE KING OF METALS

Iron is the most useful and necessary of all metals. For that reason, as we like to think, kind of tools employed and the power acquired over the mineral kingdom. When a tribe stopped making its implements of stone and began to work in iron, it went up a long step in the ladder of civilization. It passed from the Stone Age to the Iron Age. The Egyptians and Babylonians used to call iron "the celestial metal," probably because it is very common in the meteors which fall from the sky. In the poems of Homer, iron is spoken of as something rare and precious, which was stored in the treasuries of the rich, and on one occasion a lump of

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TRAIN CROSSING NIAGARA RAPIDS ON STEEL BRIDGE

Here we have a striking example of the essential part played by iron as the master metal of our modern civilization. Without iron we would have no locomotives, no cars, no rails, and no steel bridges.

Mother Earth has placed it in almost every country and made it easier to get than any other metal. But its own properties are responsible for its kingship in the mineral world. Iron owes its place chiefly to its hardness and strength. It will stand almost any test or pressure, from the weight of a heavy train rolling over its rails to a tempering and refining for the thinnest knife blade.

One of the most interesting ways of dividing the history of the world into periods is by the iron was offered as a prize to be given at the games. Greeks and Romans used iron for weapons, pointing their spears with them; and Romans, Celts, and Britons had iron swords. One writer tells of Cæsar's ships being much inferior to those of the Britons, because the oak timbers of the northern ships were fastened together with iron pins "as thick as a man's thumb," and iron chains replaced rope cables.

If our own time could be given any one name to rank it in civilization, it might be called the

Age of Steel. Steel is so much more valuable for practical purposes than iron, that while more iron is mined than ever before in the history of the world, the object of most of this mining is to produce material for manufacturing steel. Bessemer's discovery of a simple way to manufacture steel has gradually transformed the machinery of the world. In the production and manufacture of steel the United States stands head and shoulders above any other nation. In the middle of the nineteenth century Germany had produced more steel than America; now the United States has a yearly output of more than twice as much as that country.

Our greatest iron fields lie in the Lake Superior region, and in Missouri, Alabama, and Pennsylvania, though iron ore in smaller quantities is found in many sections of the United States. So important has the industry of iron and steel become to this country that it has been described as "a sort of barometer of trade and national progress."

THE NEXT MOST IMPORTANT METAL

To say that of all the metals dark, heavy iron is the most precious is surprising enough, but for second in value, if not first, we should certainly expect to put gold. The ancients would have done this. Of the six metals which they knew — iron, copper, tin, lead, gold, and silver — they put gold and silver highest. But to us copper is even more precious than gold. This does not mean that a coin made of copper would be worth as much as a coin made of gold. But if all of the copper in the world were magically spirited out of existence our daily lives would be affected much more than if the same thing were to happen to the world's gold.

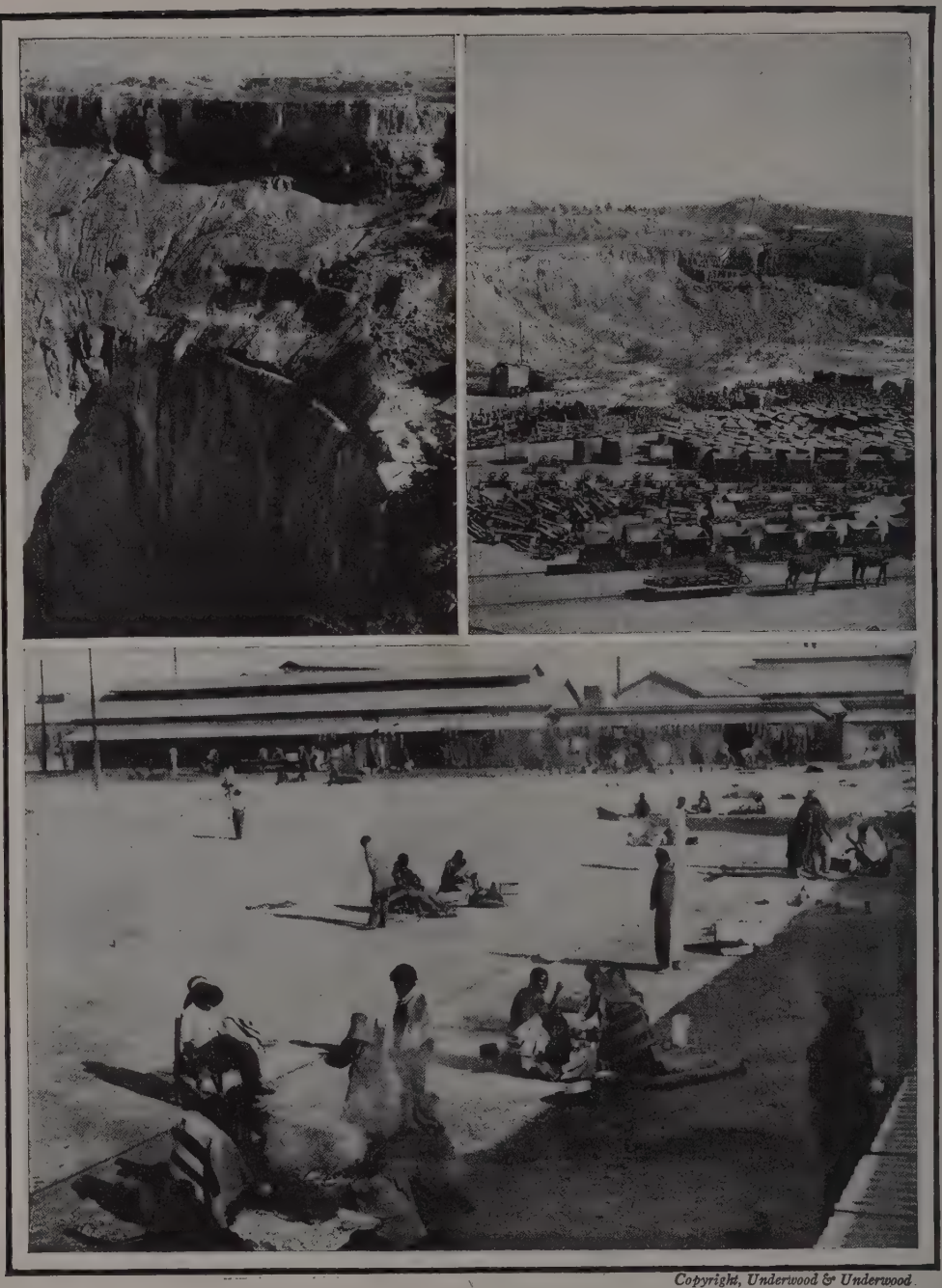
Do you know what daily, almost hourly, use you make of copper? Probably you think you do not depend on it at all; but you do. Copper is one of the best conductors of electricity. The wires of telephones and trolley lines are made of this reddish metal, which is very strong, and easily worked. So we Americans are very fortunate to have what are probably the richest copper deposits in the world. It is found in its free state in the Lake Superior region, and in combination with other minerals in many western states. Besides its use for copper articles, like wires and boilers and cooking utensils, copper is an important part of brass, bronze, and gun metal.

GOLD

For many centuries and in nearly all parts of the world, gold has been used for rings, settings for precious stones, and other articles of personal adornment. Also for the more valuable coins. Gold is prized partly because of its beautiful yellow luster, and partly because it is scarce and hard to get. Gold is excellent for jewelry and ornamental objects because it is "malleable," which means easily worked into shape, and because it neither rusts, like iron and steel, nor tarnishes, like silver. It is suitable for coinage partly for those same reasons, but chiefly because it is rare and valuable yet not too rare nor too valuable. Platinum is more valuable than gold but there isn't enough of it to serve for coins. On the other hand, if iron were used for money, a dollar would be so big and heavy that you could scarcely carry it. For many centuries the various nations of the world issued gold coins and there are a still great many of them in existence. Today, however, most nations keep their monetary gold in their treasuries in the form of bars or "bullion." They then issue paper money in place of it. In the United States gold was "nationalized" in 1933. It is now illegal for private citizens to possess gold coins or gold certificates. They must be exchanged at the Treasury for other forms of money.

OUR NATIONAL MINERAL WEALTH

If we went on through the list of metals, we should find that the United States is exceptionally rich in almost every one. It contributes yearly the second largest amount in the world to the supply of silver, with Mexico standing first. It leads the world in zinc and lead, comes second in gold, and furnishes large amounts of almost every known metal. Much of the prosperity of the United States depends on its underground wealth, and of this we have touched only a small part when we speak of the metals, for the minerals which are non-metals are immensely valuable. The most important non-metal is coal, of which we mine at present more



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TOP: THE "GREAT HOLE" AT KIMBERLEY MINE, SOUTH AFRICA, AND PART OF THE WESSELTON DIAMOND MINE. IN THE FOREGROUND ARE MANY DISABLED TRUCKS. BOTTOM: THE COMPOUND, A LARGE, INCLOSED AREA, IN WHICH ARE CONFINED THE MINERS IN THE DE BEERS DIAMOND MINES AT KIMBERLEY

than any other country. Great undeveloped coal beds exist in China, Peru, Alaska, and other eastern lands. We have also some of the richest oil fields in the world, and we furnish more than half of all the petroleum which is produced. We produce more salt than any other nation, and still have not enough for our own use. We have great treasures in building stones, and so the story might go on, showing in every case what a wonderful country we live in.

PRECIOUS STONES AND GEMS

Gems are always fascinating. Cut and polished as we see them in jewelry, they catch light and reflect it, and give a wonderful play of color. But if they are wonderful in their finished form, how much more wonderful it is that these beautiful rock crystals are tucked away in hard, unlovely rocks of wholly different kinds. The Latin name for gem, *gemma*, means also a bud, as if these were buds in the rock which would blossom forth in the hands of the jewel cutter as a bud comes up from the dark ground and becomes a beautiful blossom.

WHAT MAKES A STONE PRECIOUS?

A perfect gem-stone must have three qualities — beauty, rarity, and endurance. A real precious stone of the first order could never wear out. As we tell the story of some of the most famous gems, you will see that it is not an idle fancy that gems which are being worn at the present time may have been worn three and four thousand years ago by Babylonian kings or Egyptian ladies. It is a strange thought that the life of a gem, like the life of Mother Earth herself, is infinitely more stable and enduring than that of any living creature.

The beauty and value of gems depend mainly on their color. This may mean color in the sense in which we ordinarily use it, of being red like a ruby or garnet, or it is more likely to refer in the broader sense to their power of reflecting light. The diamond has no color of its own, but it reigns supreme in the kingdom of precious stones because of its marvelous "fire," sparkling with every movement from brilliant blue to glowing red. Other colorless stones, like white sapphire, topaz, and rock-crystal, reflect light brilliantly, but none of them glow like the diamond, with gleams of hidden fire. In some stones the color is so fixed as to remain constant in all lights; in others, the shade changes under artificial light. But the color of stones is what has given most of them their names.

Because we human beings are made as we are, we also set great value on anything which is rare. If diamonds were as common as their near relative in the mineral kingdom, coal, we should take them for granted and not prize them so highly. It is because gems are tucked away in the rocks and are rare and hard to find that we count them of so much value.

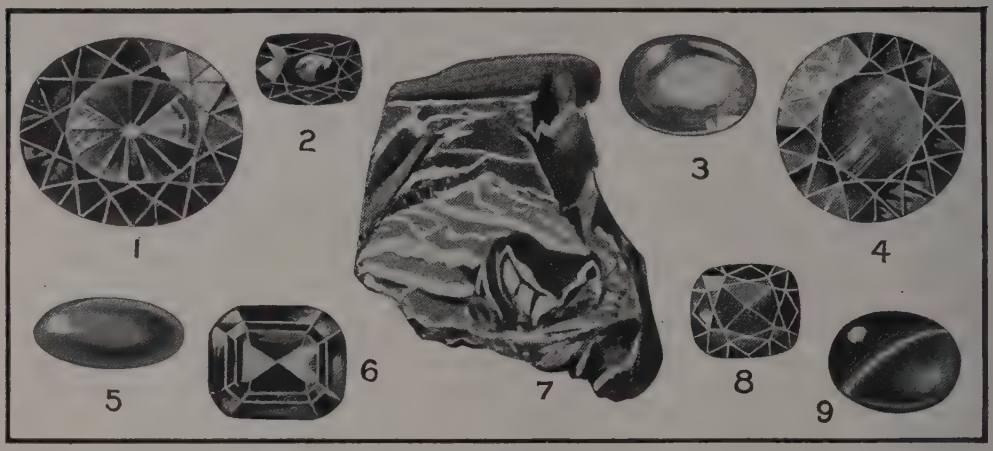
HOW CHILDREN FOUND THE WORLD'S GREATEST DIAMOND FIELDS

Boer children at play, and an African shepherd boy, were the ones to bring to notice the world's greatest diamond fields. In ancient times India was the diamond center of the world. In the eighteenth century Brazil took its place. Then in 1867, seventeen years after the discovery of gold in California, the children of a Boer farmer, Daniel Jacobs, living on a river bank in South Africa, picked up in their play a pebble which was destined to mark a new epoch in diamond mining and change the whole history of South Africa.

These children, playing in the shallow water, gathered up handfuls of pretty stones and took them home for playthings. One which they showed to their mother was so bright and of such peculiar shape that she suspected that it might be worth something. She happened to mention the find to a neighbor, Van Niekirk, who asked to see it. But the children had lost it, and it was not until after a long search in the yard that it could be found. Van Niekirk agreed with Mrs. Jacobs that it looked as if it had some value, and offered to buy it. But the family would not hear of taking money from a friend and neighbor for a bit of rock. They laughed at him and told him to "sell it and make his fortune."

THE TRAVELS OF AFRICA'S FIRST DIAMOND

The stone contained a fortune, but the trouble was that no one would believe it. Van Nie-



SOME OF THE FAVORITE GEMS

1. Chrysoberyl. 2. Tourmaline. 7. Black opal. 3. Moonstone. 4. Amethyst.
5. Turquoise. 6. Zircon. 8. Fire opal. 9. Cat's eye.

kirk turned it over to a trader, John O'Reilly, who was to dispose of it and give him half the profits. O'Reilly took it up to Hopetown, but was laughed at by everyone to whom he showed it. All admitted that it was an unusually pretty stone, and of a queer shape, but they thought it merely an odd rock-crystal. Still O'Reilly could prove that it would do things that no other stone in South Africa would do. It was so hard that it would cut glass, and O'Reilly cut his name in more than one window pane in Hopetown for the benefit of admiring groups of spectators. This should have made them suspect what it was, for it is one of the most familiar properties of a diamond that it is hard enough to make a mark on glass.

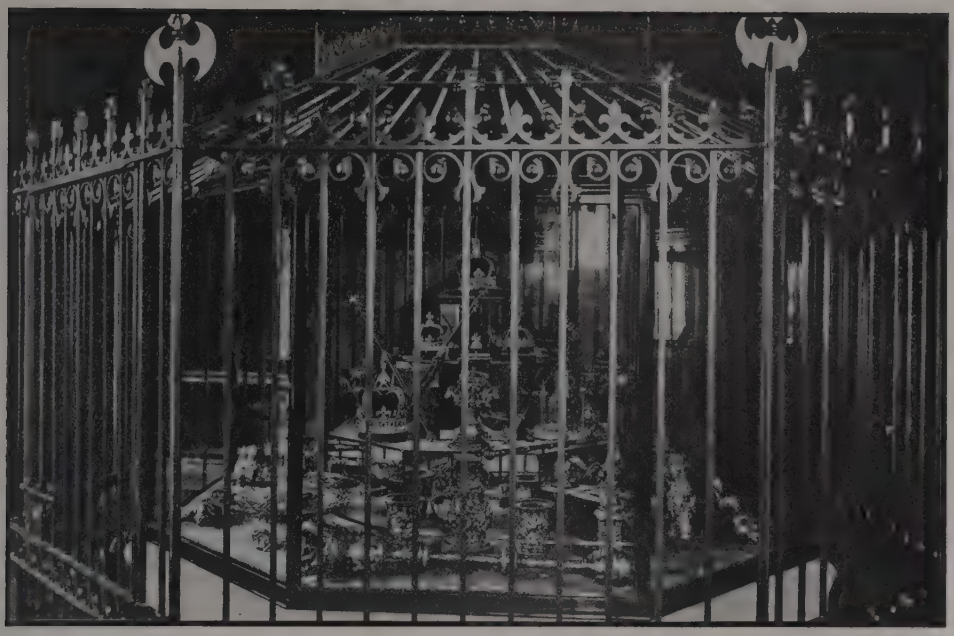
Finally O'Reilly gave it to an English official, who agreed to send it to a mineralogist, but had so little idea that it was of any special value that he sent it off in an ordinary gummed envelope. The mineralogist tested it and found that it was a fine diamond, weighing twenty-one carats. The diamonds which we usually see in rings weigh from half a carat to a carat. So this was a really valuable one. The mineralogist took it to the English governor, who bought it for twenty-five hundred dollars and sent it to the Paris Exhibition of that year.

Still no one believed that this was more than a stray diamond, such as had been picked up in many remote parts of the world. But Van Niekirk kept his ears open for more tales of strange stones, and two years later he heard that a shepherd boy on a farm near the same river had found an even bigger stone. Van Niekirk hurried to the spot and purchased the stone from the boy for five hundred sheep, ten oxen, and a horse, which was to the boy untold wealth, but not worth one tenth of the fifty-six thousand dollars which a Hopetown firm paid for the stone. In London it would have brought even more, for this was the famous "Star of South Africa," weighing in the rough uncut state eighty-three and one-half carats.

FAMOUS DIAMONDS AND THEIR JOURNEYINGS

Diamonds which when cut weigh more than one hundred carats are so few that their history is kept just as the history of families and nations is followed. These treasures have played no small part in the molding of history. Diamonds have been pledged for ransom, and their possession has changed the outcome of wars by supplying wealth at a needed time. The story of precious stones is one of the most romantic chapters of history.

The old mines of India were the source of most of the gigantic world-famous diamonds, and of these none is more celebrated than the



CROWN JEWELS OF ENGLAND IN THE TOWER OF LONDON

These jewels, of vast value, are many of them on the crowns of the sovereigns.

Koh-i-noor, meaning "Mound of Light." Its actual history can be traced back to the year 1304, when it was in the possession of the Mogul emperors; and legends carry it four thousand years back of that. It passed into the hands of the Persian conquerors of India in 1739. In 1850 it came to the East India Company, in whose name it was presented to Queen Victoria. It has since been the private property of the British royal family, and is kept in the Tower of London.

The Pitt diamond, which is the property of the French government, was found in India by a slave who concealed it in a hole he cut in his leg for the purpose. He escaped to the coast with it and offered it to a sea captain on condition that he take him to a free country. It passed through the hands of a Parsi merchant, was bought by an English governor, sold to the Regent of France, stolen during the French Revolution, and then restored by the thieves, who probably had no way of disposing of so famous a stone without detection.

One of the finest diamonds in existence, the Orloff, forms the top of the imperial scepter of Russia. It was once one of the eyes in a statue of Brahma, in an East Indian temple, and was stolen by a French soldier. He sold it for ten thousand dollars to the captain of an English ship. It was then sold in turn to a London dealer, and a Persian merchant. This fortunate man sold it to Prince Orloff of Russia for the fabulous sum of four hundred and fifty thousand dollars and a yearly income of twenty thousand dollars for the rest of his life. Prince Orloff presented it to Catherine II of Russia.

THE LARGEST DIAMOND IN THE WORLD

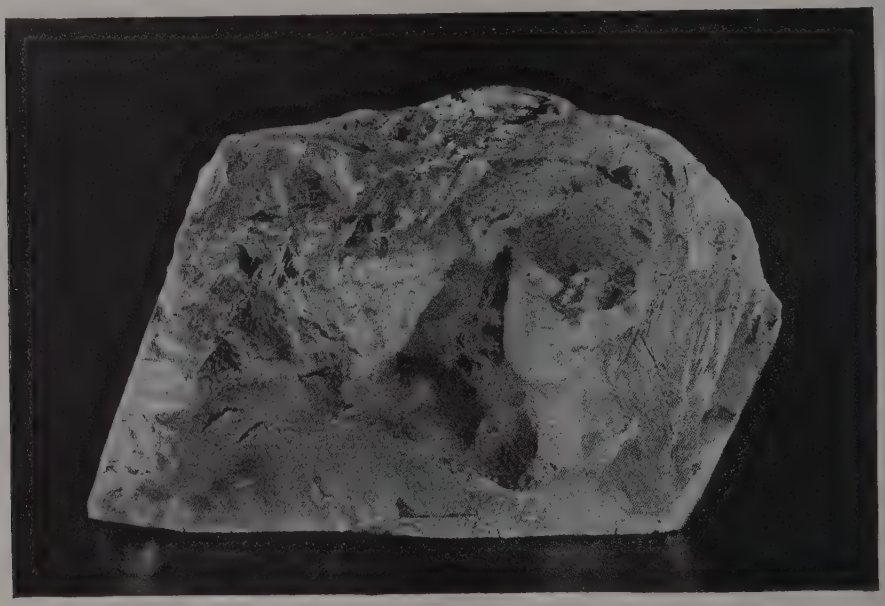
The heaviest diamonds previously found are small when compared with the colossal Cullinan, or Star of Africa, which came to light in South Africa, in 1905. This diamond, a picture of which we give in its original form, has been cut up since its arrival in England, and the stones belong to the crown jewels of Great Britain. In its rough state the stone

weighed over three thousand carats, about a pound and a third. It was purchased by the Transvaal government for seven hundred and fifty thousand dollars, and presented to King Edward VII on his birthday.

OTHER PRECIOUS STONES

Precious stones played an important part in all ancient history. Not only were they prized for their worth, but they were believed to have special virtues and to bring good or ill fortune to their possessors. Until within a couple of hundred years these stones have been valued almost as much for the mysterious powers which they were believed to possess as for their beauty.

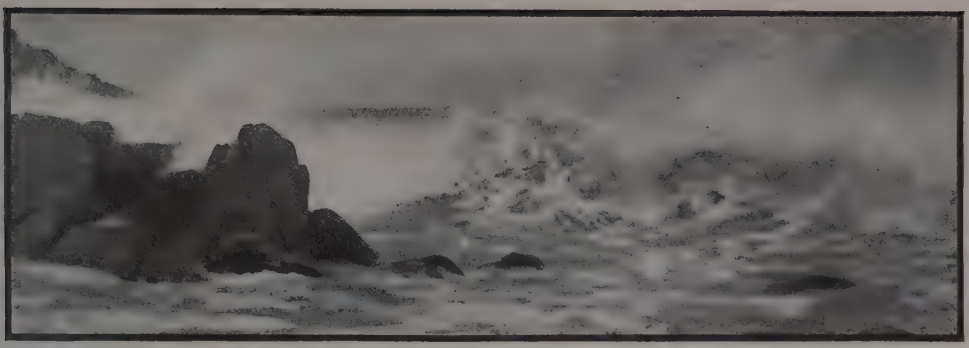
Oriental kings often retained their thrones by keeping in their control regions rich in precious stones, which brought them a yearly revenue. The ruby mines of upper Burma were jealously guarded by generations of Burmese kings. The Cleopatra emerald mines of Egypt were lost for many centuries, but were again discovered by an English viceroy. When the Spanish conquered Peru, they seized thousands of emeralds from the temples and private treasure chests. The natives bitterly resented their barbarous treatment by the Spaniards, and refused to tell where the mines were from which the gems were taken, and it was a long time before by diligent search the invaders came upon one of the Colombia mines, which has been worked almost continuously during the four hundred years since the Spanish entered South America, and has yielded vast rewards.



CULLINAN DIAMOND, THE "STAR OF AFRICA"

New stores of precious stones are discovered every few years. In 1889 a hunter, tracking a wounded kangaroo in New South Wales, happened to pick up a beautiful opal. The region was so dry and barren that it would not have been explored except by some such chance; but thousands of opals were tucked away in the seams of the rocks.

So there are many chapters in the Wonderbook of the Earth which have not been read as yet. The interest is always keen to penetrate as far as possible into Mother Nature's mysteries, and gain what we can of knowledge and of hidden treasures.



THE SEA AND ITS MARVELS

THE STORY OF WINDS AND WAVES, TIDES AND CURRENTS, SAND AND SHELLS; OF MARINE LIFE AND MONSTERS, AND ALL THAT IS IN THE DEEP

HE sea has always been a marvel and a mystery to man. Vast and limitless beyond anything which he knew, with depths which he had never fathomed, it stood to him for something beyond himself, that he could neither measure nor conquer.

Man might travel across the ocean in his tiny ships, but he left no trace behind him. It was still the pathless deep. He might study its waves and explain them, and its tides and tell their cause; but when he was through, there was the sea, vast, sublime, and majestic, untamed and untamable.

"In all time,
Calm or convulsed, — in breeze or gale or storm,
Icing the pole, or in the torrid clime
Dark-heaving; boundless, endless, and sublime —
The image of Eternity, — the throne
Of the invisible; even from out thy slime
The monsters of the deep are made; each zone
Obeys thee; thou goest forth, dread, fathomless, alone."

In myth and legend the world begins always with water. Earth was pictured by the ancients as an island set in the midst of an encircling ocean. Indian myths say, "In the beginning all was water; there was no land at all." Scientists do not know how much of the earth was at first covered by water. But we may be sure that in those early ages, just as to-day, the extent of the oceans far surpassed that of the lands.

Many think that life began in the sea. Yet it is only within a few centuries that we have come to know very much of life under water. The ancients pictured strange sea monsters, serpents and harpies, half human and half creature, dwelling in the deep. But of the wealth of actual life in the sea they had no idea. Pliny, the Latin writer, counted one hundred and seventy-six kinds of creatures which he found in the waters of the Mediterranean, and was sure he had told them all. In the aquarium at Naples to-day you could probably see as many thousands.

And so the ocean has come to mean more to us than it could to our ancestors. We have not lost our awe and wonder; they have only deepened as we have learned more. But we have come farther into its inner chambers. It has shown us more of its secrets. To us more than to any people who have ever lived on the earth the wonders and treasures of the deep have been laid bare.

THE COLOR OF THE SEA

The usual color of sea water is blue, but a sudden gust of wind, a dark cloud, a blue sky, animal or vegetable life, as well as the nature of the sea bottom, give it almost every possible color at times.

The greenish color of shallow water is due to the yellow of the sand shining through the natural blue tint of the water. The degree of saltness as well as the depth of the water affects the richness and hue; thus, the waters of the trade wind region, rich in salt, are dark blue, while the slightly fresher waters of the Arctic region are paler. Some of these colder waters are greenish because of the quantities of very minute plant life which they contain.

Besides these different colors in the open sea, certain areas have peculiar colors due to local causes. Thus the Yellow Sea, off China, is named from the color given to its waters by the vast amount of mud brought down by the great rivers emptying into it. The Red Sea takes its name from the reddish tint along its coralline shores. A reddish color has been noticed in the South Atlantic, off the mouth of the La Plata, as well as in certain parts of the Pacific. Sometimes the waters of the Gulf of Guinea are whitish, while in the northern seas, off Greenland, streaks of green and blue are striking.

THE EVER RESTLESS SEA

One of the things that strike you as you look upon the ocean is the fact that it is never absolutely still. Even when there is not a breath of air the waves come gently lapping on the sands. Then, when the wind blows high, waves rush towards the shore to break with a roar upon the beach. While man has not been able to invent a machine that would go forever without stopping, the sea shows him incessant motion.

OCEAN WAVES

Of the three movements of the sea — waves, tides, and currents — the waves are the most familiar. There are always ripples on the sea, because there is always at least a slight movement in the air, and, wherever the gentlest breeze strikes the water at an angle, it makes a little depression. This depression in one place is followed by a rise in another. This rising and falling of the sea surface makes the waves.

As you sit on the beach and watch the waves rolling in one after another, it looks to you as if the water itself were moving from far out on the ocean toward the land. But if you watch a stick of driftwood or a piece of seaweed which may be floating at a distance from the shore, you will see that it merely bobs up and down as the waves pass by. This means that the water itself has only an up-and-down movement. Because each depression caused by a downward movement is followed by the elevation of an upward movement, the wave effect is produced. Children secure the same kind of result when they tie one end of a "jump rope" and move the other end up and down with their hands.

It is only when the ocean waves approach the shallower waters of the coast that the decrease in depth causes the mass of water itself to rush forward up the beach or against the cliffs.

Waves forty-three feet high have been measured in the North Atlantic Ocean. In the South Atlantic, off the Cape of Good Hope, they have been reported fifty and sixty feet high. The height of an ordinary wave with only a moderate wind is about six feet from crest to trough. In our study of light waves we have learned that wave lengths are reckoned from the top of one wave to the top of another. Sea waves have a wave length varying from ten to twenty times their height. Waves four feet high will have their crests about forty feet apart; those thirty-three feet high about five hundred feet apart.

THE SALT IN THE SEA

Everyone who has bathed in the sea knows that its waters are very salt and somewhat bitter. To explain where the salt came from has been an age-long puzzle. It is probable that, when great quantities of water vapor condensed to form the first seas, many salts were dissolved from the rocks which formed the bed and the shores of the ocean. If this is so, the ocean has been salty to some extent from the beginning. During all of the ages since its first appearance, it has received contributions of

ON THE NORTH SHORE OF THE ATLANTIC

Where the surf breaks on the rocks, and in storm the spectacle is grand beyond description. Painters frequent this rockbound coast.

WAVES BREAKING ON A ROCKY COAST

minerals from the land. Streams have dissolved mineral salts from rocks and from the soil surfaces and have carried them to the sea. Even rain may add to the salt supply by washing from the air gases that are given off from volcanoes. These gases unite with substances which have been carried into the ocean from the land, thus producing salts.

WHAT IS SEA SALT?

Yet the salt of the sea is not merely our common table salt. It contains many other substances, such as magnesia, iron, lime, sulphur, copper, potash, ammonia, and silver, in actual amount small only in comparison with the salt. For example, although the proportion of silver contained in sea water is so little, the ocean itself is so immense that, it has been calculated, if all the silver of the sea were collected, it would form a mass that would weigh about two hundred million tons.

It was knowledge of the presence of this silver and other mineral grains in the sea water that made it possible for an ingenious swindler to lead many people to believe that gold could be gotten out of sea water in quantities large enough to make all the stockholders in his company rich. But all the gold he got out of the stream of sea water drawn through his secret mill on the Maine coast was what he put in, as the unfortunate folks he deceived finally found out.

The saltness of the ocean varies slightly in different parts. Water evaporates more rapidly near the equator than in the colder regions because of the greater heat of the tropics. Since salt is not removed by evaporation, the ocean in the torrid zone is salter than in the temperate or the frigid zone; but the difference is not so great as might be expected.

It is because salt makes the sea more dense that salt water is more buoyant than fresh water. This is a great advantage in the matter of ocean commerce. Since a ship of given weight does not sink so deep in the sea as it does in fresh water, a vessel can carry more cargo on salt water than it would be able to do on fresh water. Again, because of the greater support afforded by salt water, it is easier to swim in salt water.

CAN WE GET THE SALT OUT?

One great disadvantage in the saltness of the sea is the unfitness of its water for drinking. Every seafarer has had occasion to recall those famous lines in Coleridge's "The Ancient Mariner":

> "Water, water, everywhere
> And all the boards did shrink;
> Water, water, everywhere,
> Nor any drop to drink."

Since that time we have learned to get fresh water from salt water by distillation.

Once a ship's captain lost his whole supply of fresh water by accident. Before he could put into port and get a fresh supply, a gale of wind, which lasted for three weeks, drove him far out to sea. He had no distilling apparatus on board. He would have to invent some way to get the salt out of the water or die. So he took an old iron pitch-pot with a wooden cover for a boiler, made a pipe of pewter plate, used a wooden cask as a receiver, and set to work. He filled the pot with sea water, put in an ounce of soap, thinking to purify it, and placed it on the fire. When the pot began to boil, the steam passed through the pipe into the cask, where it was condensed into water. The salt particles, which do not evaporate, were left behind in the pot. In less than an hour the crew had a quart of fresh water to drink.

Many ships are now regularly supplied with apparatus for distilling sea water. In case of emergency, while on the African coast and other unhealthy stations where water is bad, the sailors drink no other water than that distilled from the sea.

THE TIDES

Whether you have ever seen the ocean or not, you have certainly heard how its waters creep steadily up the beach for six hours and then for six hours slip as steadily down the beach, all in answer to some mysterious, unseen force. The cause of this endless rise and fall of the sea was once a great puzzle; but it has now been agreed that the rising of the water, the "flow of the tide," is brought about through the ocean being drawn forward, as it were, out of its place by the influence of the moon. If the

Ewing Galloway

LOW TIDE AT ST. JOHN, NEW BRUNSWICK, ON THE BAY OF FUNDY

The twelve-foot fall of the tide, twice daily, leaves vessels stranded at their wharves as if in dry dock for several hours of the twenty-four.

earth were entirely liquid, the high and low tides would travel regularly around it as it turns on its axis each day. The waters which at any moment were directly facing the moon would bulge outward toward the moon. The waters on the opposite side of the earth would bulge outward at the same time, away from the moon. This means that there would be two high tides so placed that a line joining them would pierce the moon if it were extended far enough through space. Two low tides would appear on opposite sides of the earth from each other, each being situated half way between the two high tides. None of these tides would be particularly noticeable. It is only when land hinders the movement of the water that we notice high tide and low tide.

WHY FOUR TIDES A DAY?

The sun as well as the moon has an influence upon the tides. But the sun, for all its size, is so much farther off, that at 93,000,000 miles from the earth it does not attract so much as does the moon at 240,000 miles. The tide caused by the sun is so small as to be noticed only when the sun and moon both act on the water at once. The tides ebb and flow twice in twenty-four hours. This is because the earth goes round on her axis in that time, and brings

the same point of the ocean twice under the direct influence of the moon.

Twice in the course of every month the sun and moon come into a line with each other. This happens at new and at full moon. At these times both attract at once; that is, they draw together. At such seasons the tides rise high and are called "spring tides." At the time of the new moon, there is a spring tide because the sun and the moon are on the same side of the earth. At the time of the full moon, sun and moon produce high tides by being on opposite sides of the earth.

But when the sun and the moon are in such positions that they are pulling in opposite directions, the water is low, and is called "neap tide," or "scanty." Neap tide occurs at the end of the first quarter of the moon and at the beginning of the third.

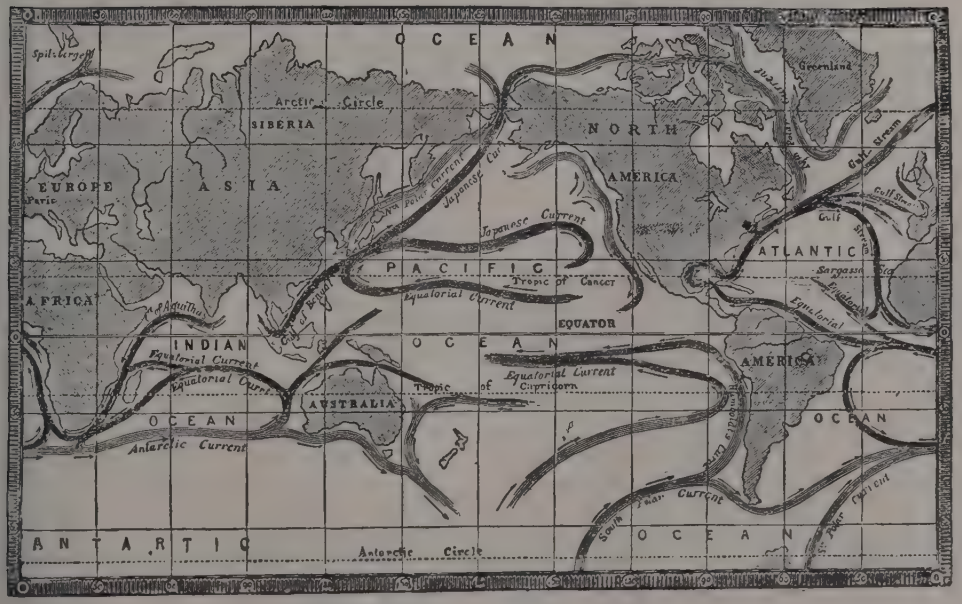
The height of the tide is affected also by other causes; thus, a strong wind coming in with the tide will drive on the waves madly. When the sea rushes in with such power as to do much damage, it is spoken of as a "storm tide." Along the flat coasts of the Netherlands the storm tides are a particular dread.

RIVERS IN THE OCEAN

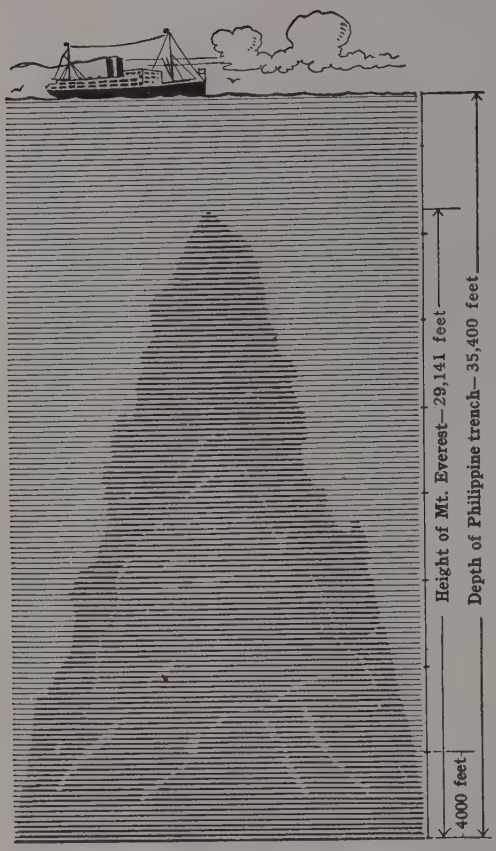
Do you ever go surf-bathing in summer? Is the water warm or cold? If you go in at Atlantic City, or anywhere along the New Jersey coast, you will find the water comfortably warm. But if you go in at Squirrel Island, a hundred miles east of Portland, Maine, you will find it very cold. What makes the difference? It is the same Atlantic Ocean, is it not? Yes, but there is a broad stream of warm water, flowing like a river in the midst of the ocean, that warms up the Jersey coast's wonderful sand beach.

A BATTLE BETWEEN CURRENTS

This mighty ocean-river, or current, is that Gulf Stream which starts in the torrid heat of the Gulf of Mexico, down near Panama, where the great canal is. Warmed by the sun of the tropics, it flows up the Atlantic coast, carrying with it warmth and genial weather. But just off the coast of Maine it meets another of the ocean-rivers. This is an icy-cold one, called the Arctic current, which starts from the



THE WORLD SHOWING ITS OCEAN CURRENTS



IF MT. EVEREST WERE PLACED IN THE PHILIPPINE TRENCH

The chart shows graphically that there would be over a mile to spare.

cold North and flows down between Greenland and Labrador, laden with icebergs and floe-ice. Now when the Arctic current reaches the coast of Maine, it sinks beneath the Gulf Stream, and its cold waters continue their journey towards the equator as a slow drift near the ocean floor.

During its course up the North American coast the Gulf Stream follows a northeasterly direction. After its meeting with the Arctic current, its northeasterly course takes it away from the American coast and across the Atlantic Ocean. Presently it divides; one branch flows towards Europe, the other along the western coast of Africa. Thus the Gulf Stream goes winding on its own proper route, with as distinct a source, course, and service as the Hudson River or the Mississippi. Before it has made its way back to its own warm gulf again this ocean-stream makes a journey of twenty thousand miles.

The ocean is full of these currents, cold or warm, each after its kind. And strangely enough, even though in the torrid zone the water is so warm on the surface, underneath it is frigidly cold, owing to the polar currents in the depths of the ocean.

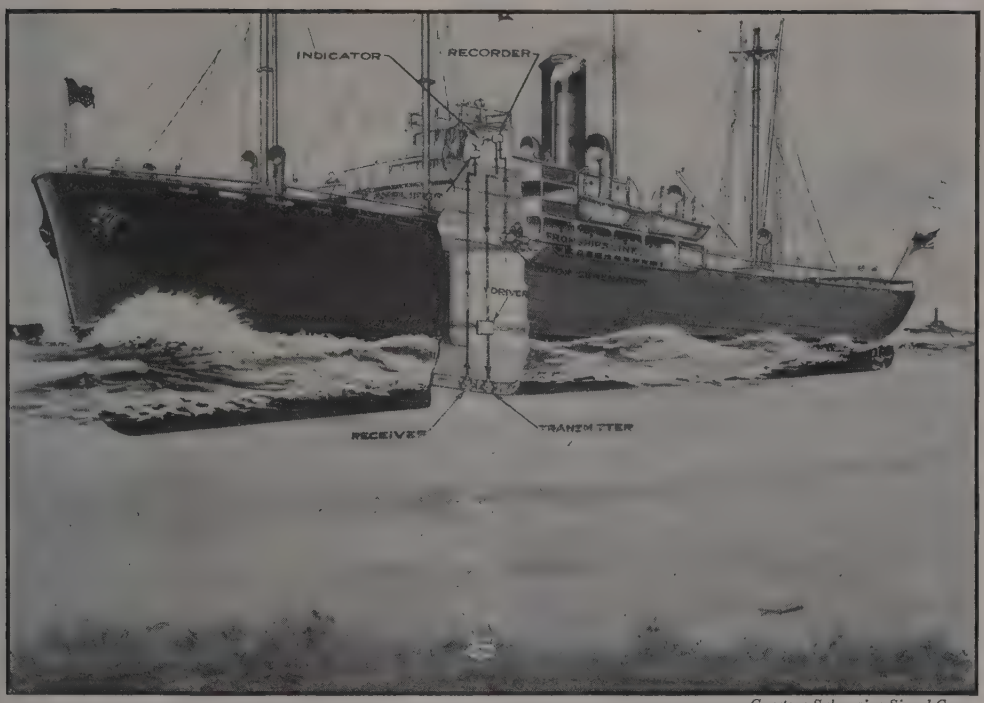
DEPTHS OF THE OCEAN

Deep-sea sounding shows the average depth of the ocean to be about two and a quarter miles. The seas are shallower than the oceans, and, of the oceans, the Arctic and Antarctic are the shallowest. The deepest known region is the Philippine Trench, near Mindanao in the Western Pacific Ocean. Soundings show this depth to be 35,400 feet, or more than six miles.

It is of interest to recall that the highest mountain, Mount Everest, is 29,141 feet; so that there is a difference of more than a mile between the earth's greatest elevation and her deepest ocean-bed.

WHERE LAND AND WATER MEET

When we speak of the depth of the ocean we mean its depth at some distance out from shore. Just as at one beach the shore slopes off gradually and at another the drop is very abrupt, so about some continents there is a great shelf running far out under the water. Such a shelf, seventy-five to one hundred miles broad, extends along the eastern coast of North America from Newfoundland to Florida, and around the shore of the Gulf of Mexico and part of Central America. The shelf on the Pacific borders is rather narrow; the British Isles rest on a high northern shelf. When these shelves are in latitudes where there is a cold climate, they make the world's best fishing grounds. The great Newfoundland fishing banks are on such a wide land formation. Beyond the edge of these shelves the waters suddenly deepen and the real ocean basin begins.



Courtesy Submarine Signal Co.

HOW A VESSEL MAKES SOUNDINGS FOR DEPTH

A device called the fathometer sends down ultrasonic waves and records the time it takes for the echo to return.

THE BOTTOM OF THE SEA

While the ocean forms one continuous body of water, it is divided into five smaller bodies, — the Pacific, Atlantic, Indian, Arctic, and Antarctic oceans. These are all formed by deep depressions in the ocean floor. The Arctic and Antarctic oceans are marked off from the others by their location around the north and south poles. The other three are separated mainly by continents. Of the entire water area of the earth the Pacific fills about one-half, the Atlantic one-fourth, the Indian Ocean one-fifth, and the Antarctic and Arctic one-seventeenth and one thirty-fifth.

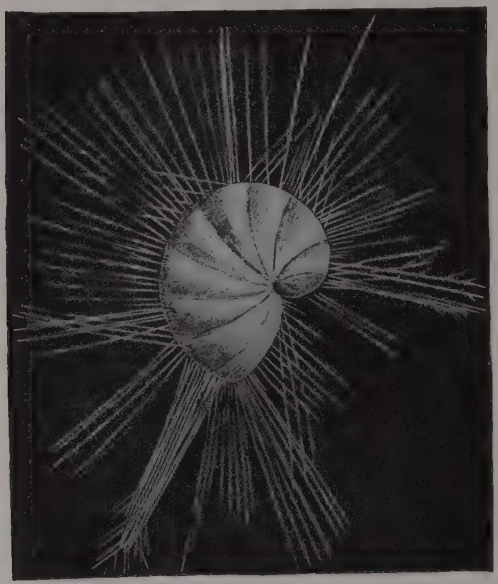
There is a natural curiosity to know what the bottom of the sea looks like. Suppose the Atlantic Ocean should suddenly dry up, what would a journey across its bed show us? It used to be imagined that the ocean bottom was much like the land surface, with plains and hills, valleys and mountains, and all sorts of grand scenery. But as the students of geology came to know that the present form of the earth's surface is largely the result of those remarkable forces of frost, wind, tide, and flowing streams, it was clear that the sea bottom, where these forces are not at work, would be different. Then for many years the deep-sea soundings and the ocean dredging have been bringing us new facts, until we have learned that the sea, away from the shore, is not unlike a gentle, rolling plain. It is said that this sea floor slopes so easily that a railroad could be built upon it without the necessity either of building bridges in any part of its course, as has to be done so often on land, or even of raising the floor to make it level for the rails.

Numerous volcanic cones, such as those that make a broken chain in the North Atlantic from Iceland to the Azores, are everywhere over the sea bottom.

WHAT IS ON THE FLOOR?

The floor of the ocean itself is made up of the many layers brought there by the rivers. For countless ages the rivers of the world have been carrying down particles of earth and rock to the sea. These the ocean currents have taken up and scattered over the ocean floor for an average distance of about three hundred miles out into the sea.

In addition to this deposit brought by the rivers, there is found in the ocean a thick,



A TINY CHALK-BUILDING CREATURE, REACHING OUT THROUGH ITS SHELL IN SEARCH OF FOOD

gray, oozy mud which covers much of the bottom. This ooze is made up of broken particles of shells and skeletons of the animals that have lived in the sea, and especially of the myriads of shells of those single-celled animals that form our chalk. Thus there is forever going on a gentle rain of tiny animal shells from the upper regions of the ocean down into its lowest depths to carpet the ocean floor.

Farther out in the great depths of the sea is found a red clay which is made up of the dust particles thrown out by the volcanic eruptions which occurred in the sea long ago, even before those old-fashioned sharks lived whose teeth are buried in it — the teeth of extinct creatures that must have lived countless ages ago, here preserved to suggest how very old this world is.

THE DIFFERENCE BETWEEN SEA SAND AND DESERT SAND

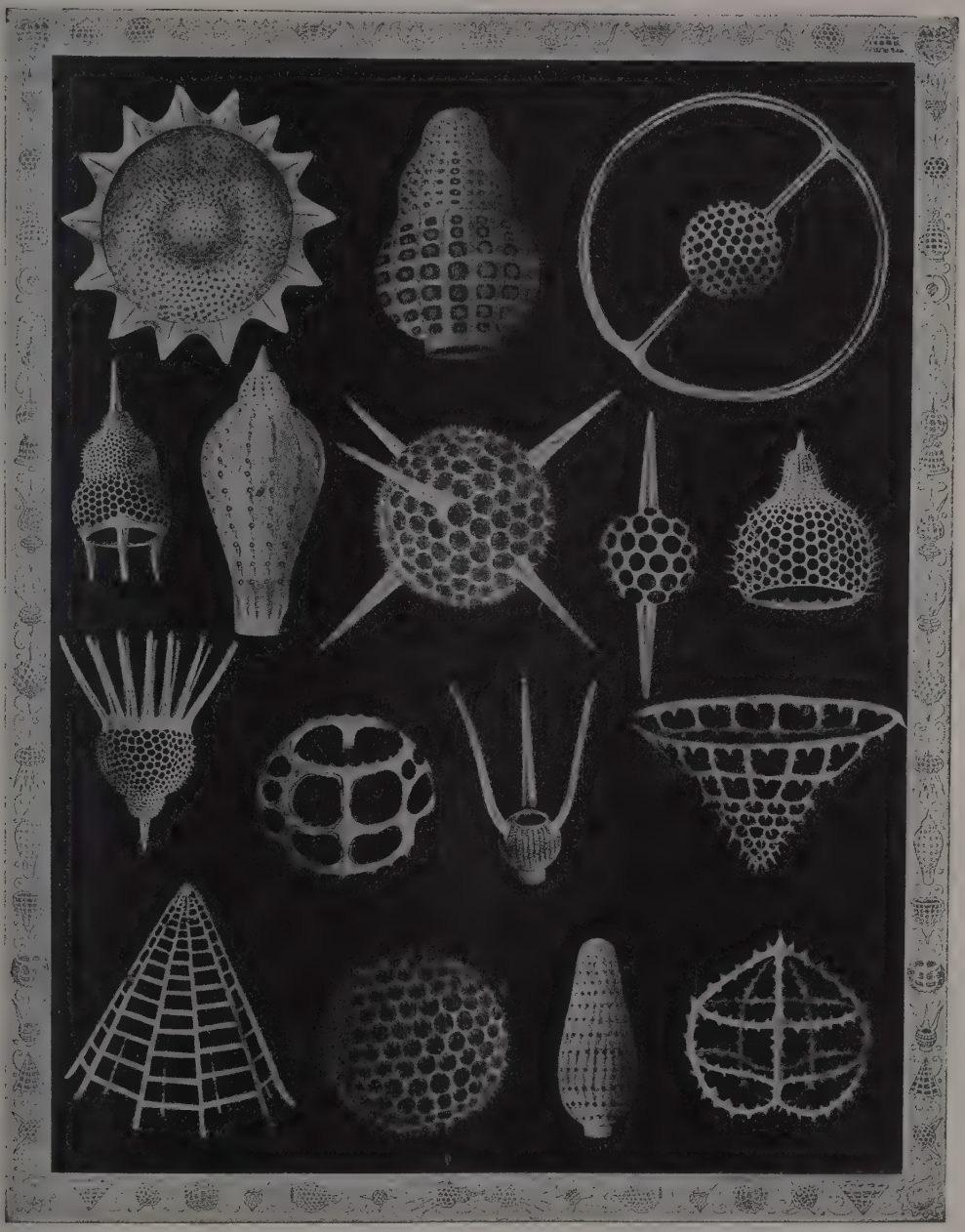
Take a handful of sea sand and look at it through a magnifying glass. You will see that the separate sands are not worn quite smooth and round, as might have been expected, but that the little grains still retain to a certain degree their once sharp angles. This is due to the wet grains, as they lie with their faces towards one another, holding a film of water between them which prevents their actually touching each other, and so grinding down all of each other's angles. If we could go from the seashore to a desert, where the sands are absolutely dry and destitute of any protecting film of water, we should find that the sands of the desert, from being blown about by the wind and rubbing together in the dry air, have become rounded and smooth and are gradually converted into fine dust.

WHAT IS SAND MADE OF?

The magnifying glass told us that sand was made up of sharp-pointed grains. That was as far as anyone could go until the microscope was invented. Now put a dozen of these tiny grains under its strong glass, and see what it will show. Most of the grains are tiny, beautifully shaped crystals of quartz which were once part of the rocks of the shore. Mixed with the quartz grains are fragments of shells of different kinds of sea animals. In some sands there are large numbers of exquisite shells so small that it would take at least a million to fill a lady's thimble. They were once the homes of living animals, about which we shall read in the story of "Life in the Sea."

FRESH-WATER SPRINGS IN SALT WATER

In the waters of the Atlantic, some miles south of Cuba, a fountain of fresh water bubbles right up through the salt water of the ocean. There is another off the coast of Italy. In both



TINY SEA SHELLS, MAGNIFIED UNDER A POWERFUL MICROSCOPE

The sand of the sea bed contains tiny perfect shells so small that to the naked eye they look like powder. Once the home of the lowest form of living creatures, it would take a million of these shells to fill a lady's thimble.

A WATERSPOUT ON THE SOUTH ATLANTIC OCEAN

cases the fresh water comes from springs that are fed from below the ocean-bed. The water of these springs trickles for miles perhaps under the surface of the earth; then, not finding an outlet upon the surface of the land, the spring breaks through the bottom of the ocean. What makes the water rise? As, by nature, fresh water is lighter than salt water, it rises to the surface of the ocean, just as oil floats on the top of water, or cream rises on milk. This rising of the fresh water is further helped on by another of Nature's ways: since the water of these under-ocean springs comes down from greater heights, it is bound to seek to rise as high as its source. And so we have these rare submarine springs, seeming miracles until you think out the reason for them.

LIGHT IN THE OCEAN

Since sea water is partly transparent, some light passes through its upper layers. There is considerable light to a depth of about 600 feet. This part of the ocean is the best region of the whole earth for allowing the mingling of large numbers of living things. At the 600-foot level the light is rather feeble. Twilight, becoming dimmer and dimmer, extends down to about 3000 feet. The great deeps are inky black except for the dim glow given off by an occasional animal.

Besides the never-changing night in these depths, there is eternal cold and silence. There is only slight motion, for the restless waves and the great ocean currents are found only at the top of the water.

STORMS AT SEA

Many tales have been written and told of storms at sea. Every year the Weather Bureau prevents much damage to shipping by foretelling the approach of storms. On the south-eastern coasts of North America and of Asia, storms of great violence occur each year during the months between July and October. Those that arise in the West Indies are known as hurricanes. They are great whirls of air in which the winds blow with tremendous force. Often, after they have lashed the sea into violence, they travel over the land and produce wreckage. Hurricanes arising near the Philippine Islands are called typhoons. A ship overtaken by a typhoon is wrenched and tossed about in a frightful manner. The deafening noise of the howling winds and the roaring waves combine with the plunging and straining of the ship to make the experience one never to be forgotten by any person who has been through it.

An experienced sailor may not be at ease even when a lull comes. If he knows that the ship has passed through the edge of the storm he rejoices. But the lull may mean that the ship is in the "eye of the storm" — the center about which the storm is swirling. This center is

a region of rising air currents and therefore has no wind. But a sailor knows that the only way to escape from this calm region is to pass through the other side of the storm, and he can only hope that the ship will hold together until it is through.

Tornadoes occur at sea as well as on land. They start in the upper layers of the atmosphere when two layers of air blow strongly in opposite directions. This causes a whirl with a very rapidly rising column of air in the center. Such storm whirls are usually small in diameter, but they may cause severe damage in a narrow path: A tornado over the ocean has long been called a waterspout because the water leaps upward to form a high column in the central region of rising currents.

TRADE WINDS

To say that a person is as changeable as the wind is to forget that, changeable as the wind *seems*, it is under the complete control of natural forces, and travels, not by chance, but in entirely regular tracks.

Winds are due first of all to the fact that heated air has the same tendency to rise over the great torrid belt of the earth that it has in the rooms of our houses. Now, when this heated air of the tropics rises in columns over the torrid zone and spreads north and south toward the poles, the space from which it has come must be filled by colder air. This colder air comes from regions in the north and south temperate zones, which are constantly sending air currents toward the equator and the poles.

As the winds from these cooler regions approach the equator, they are turned from their direct north and south courses because the earth is spinning eastward faster at the equator than at any other place. There is an increasing difference between the rate of the eastern motion of the air which is approaching the equator and that of the eastern motion of the earth itself. Because the earth is moving the faster, the air is turned toward the west. Thus the winds which started blowing from the south become southeast winds, and those from the north become northeast winds. These great currents of air sweep steadily in a westerly direction over the oceans near the equator and are known as the "trade winds." They received their name because of their aid to shipping in the days of sailing vessels. They are not so noticeable on the continents as on the oceans because such features as mountains, deserts, and inland bodies of water produce local winds as well as offering obstructions to the trade winds.

It was the trade wind that gave Columbus so much anxiety on that first voyage to the New World. He could not but wonder how he would ever get back if this wind blew always in one direction.

THE MONSOON

In certain regions the direction of the trade wind is periodically changed. The temperature of the interior of continents is colder in winter than that of the ocean. In summer continents are warmer. Usually this difference of temperature does not have any noticeable effect on the winds of the region. The character of some regions, especially the presence of mountains, causes such a marked temperature difference that winds blow strongly from the land in winter and toward the land in summer. Such winds are called "monsoons." They occur over Australia, Spain, and southeastern America, but are especially famous in connection with India. In winter, air moves outward in all directions from cold Siberia. This causes the dry northeast monsoon in India. Its great strength forces the northeast trade wind to blow across the equator.

In summer India becomes much warmer than the ocean. The wind at that time blows over the country from the southwest. The Himalayas aid the rising warm currents, and the wind blows with terrific force, bringing deluges of rain. Ships dare not face the lashing gale. The northeast trade wind is reversed, joining the southwest monsoon. The change in pressure causes the southeast trade wind to cross the equator and become a southwest wind.

THE REGION OF CALMS

The region between the two belts of trade winds is called the "Region of Calms." It is a more or less shifting zone from one hundred and fifty to six hundred miles wide, according to the longitude and the season. In March

LARGE FIELD OF ICE WITH DETACHED ICEBERGS

the center of the calm-belt is at the equator. Here the air is that dull, dead calm, more dreaded by the sailor than almost anything in Nature; especially after he has been sailing over a flowing ocean, rippled by the welcome breath of the trade wind, the bright blue sky overhead unflecked by a single cloud.

Suddenly comes a change. The sky is overcast. The waves cease to be tipped with silver foam. A belt of heavy cloud overhangs. The winds are hushed; thick vapor rests motionless in the air. The surface of the sea is like lead. The sailor feels oppressed, half-choked by the weight of the air. It takes the poet to describe it:

"Down dropped the breeze, the sails dropped down,
'T was sad as sad could be;
And we did speak, only to break
The silence of the sea.

"Day after day, day after day,
We stuck, nor breath nor motion;
As idle as a painted ship
Upon a painted ocean."

Then it may be a furious tempest breaks, and the rain pours down in such torrents that the sailors can scoop up fresh water from the surface of the sea.

"Doldrums" is another name for this Region of Calms. A depressed person is sometimes said to be "in the doldrums." This expression has lived from the time when it described the feelings of sailors who were prisoners in this region until the wind filled their sails.

ICEBERGS

The polar land-regions of the earth are covered with a thick, moving ice-cap, forming "glaciers." The ends of these glaciers are all the time pushing out from the land until they overhang far into the sea. In time, as these overhanging parts are beaten by storms and worn upon by the action of the water, great masses are broken off. Thousands of these fragments, broken off from the southwest coast of Greenland, are caught and held for a time by the floe-ice in the land-locked waters between Baffin's Bay and Greenland. When the southwest wind unlocks the Arctic gates, these fragments of glaciers break from their moorings and sail southward, a magnificent fleet of hundreds of icebergs. While the greater part never get farther than the Labrador coast and northern Newfoundland, a small number, helped on by wind and current, make their way into the Gulf of St. Lawrence or sail on to the southward, to be watched for by anxious sea-captains, as the single remaining terror of all those monsters, real and fabled, that once filled the sea.

Icebergs are larger than they seem, for only one-ninth of them shows above the surface of the water. As they are worn away by the waves they deposit on the ocean floor the load of débris which they gathered from the earth when they were parts of glaciers.

But are there no other icebergs than those made by the Humboldt Glacier in the Greenland berg-factory? Yes, more and larger ones are built by the Antarctic glaciers. The reason we hear so little about these and about the few and smaller ones of the North Pacific is because they seldom make their way into the great traveled ship-roads of ocean, owing to the small help they get from ocean currents. The Arctic Current and the Gulf Stream are

responsible for the yearly menace of four months of icebergs in the North Atlantic during shipping's rush season.

The United States Coast Guard maintains a patrol off the Grand Banks, to locate icebergs and notify vessels of their positions. A story of a day on one of these ships is told by Kenneth Payson Kempton in "Adventures of To-day and Yesterday," Volume Four, page 170.

WHAT MAKES THE SEA SHINE?

Some dark night, when you are out rowing in the smooth water of a sheltered cove, you will be startled to see a streak of light follow each stroke of your oar and then to see that the drops falling from your oar look like a shower of pearls and diamonds. Looking back you will see that the boat leaves behind it a streak of flashing light and that all about is a shining, myriad-colored radiance that makes of the whole surface of the water a fairy moving-picture indeed.

Do not be content merely with being told that this wonder-coloring is due to phosphorescence; but, with a dipper, scoop up a quart of the sea water, take it to the light, and see for yourself the million dots of color, each not larger than a small pinhead, which make up some of life's simplest children called *Noctilucæ*, "night glows." They are single drops of shine which give out sparks of light from below their outer rim. It is estimated that there are thirty thousand to a cubic inch of water containing these one-celled light-givers. Now conceive the millions upon millions in this sea, covered for miles with this glow of liquid fire!

You may ask, How do these animals give out light? Some say it is caused by a chemical change in their delicate organs, while others tell us that these creatures, although they can be scarcely seen with our eyes, have a wonderful power of changing the heat of their tiny bodies into light. Scientists are studying with interest the light given off by sea creatures because it is produced with so little heat. When we produce light in our lamps, we waste a large amount of heat in the process. The story of these "Living Lamps" is more fully told in Volume Ten, pages 237–240.

THE SEA HORSE

A tiny fish, only a few inches long, which looks like the knight in a set of chessmen.

LIFE IN THE SEA

So far we have talked about the ocean as if it were, as the ancients thought it, a vast stretch of water, inhabited only on its edges by living creatures. In just this way an inhabitant of another world might describe the formation of the earth, in mountains, valleys, continents, and so forth, and never think to mention what to us would be the most interesting thing of all — the life on the earth. It would be just as unfair to describe the ocean without showing it to be a world of abounding life.

The tiniest and the largest forms of life of which we know exist in the ocean. There are the infinitesimally small one-celled forms of life, so tiny that we can see them only under a powerful microscope, and there are the huge sea mammals and fishes, larger than any creatures now living on dry land. So there is no better or more fascinating place in which to study life than in the ocean.

Everywhere, throughout every body of water, in all parts — above, near the surface, between, in the numberless fathoms of water, and below on the ocean bed — living creatures flourish in numbers past imagination. There are barren regions, where there is comparatively little life

or very few kinds of life, even as on the earth we find deserts and waste lands; and there are tropical waters that throng with life. There are water creatures that travel from place to place; and creatures that are fastened to their rock and sand homes and can never stir. But everywhere there is life, and life of a particularly fascinating sort, because, while some of it is familiar to any seashore child, other kinds belong to water regions of which we should know nothing if it were not for the pictures and stories that deep-sea students bring us.

LIFE'S SIMPLEST CHILDREN

Countless hosts of animals live in the sea, creatures about which nothing was known until the compound microscope was able to show them to us. To such animals a drop of water is a complete world, for it may contain millions of creatures so small that they have to be made to look a thousand times as large as they actually are before the eye of man can see them. This is the wonder-work of the microscope, the instrument made up of lenses so combined that it magnifies a creature the size of the tiniest pin-point, showing it to be a living thing, moving, eating, and producing more of itself by a simple dividing up into two.

If you will slice up some raw potato in a cup of soup left from dinner and let the mixture stand a week or two you will find under the microscope, in a single drop, more marvelous forms of animal life than the greatest scientist knew about until the microscope was invented a little over a hundred years ago.

TWO WAYS TO ADD TO OUR EYESIGHT

There are two wonderful instruments we use to see with. One is the telescope, which opens to us the book of the heavens; the other is the microscope, which reveals otherwise hidden pages of the earth's storybook. Both have a word story in their names. Telescope comes from the Greek words *teleos*, or "far-off end," and *skopos*, "view." Through the telescope, then, the distant planet is brought nearer to our sight. The microscope is exactly the opposite in its effect. The Greek word *mikros* means "little," or "small," so that this instrument gives us the "little view."

THE INHABITANTS OF A DROP OF WATER

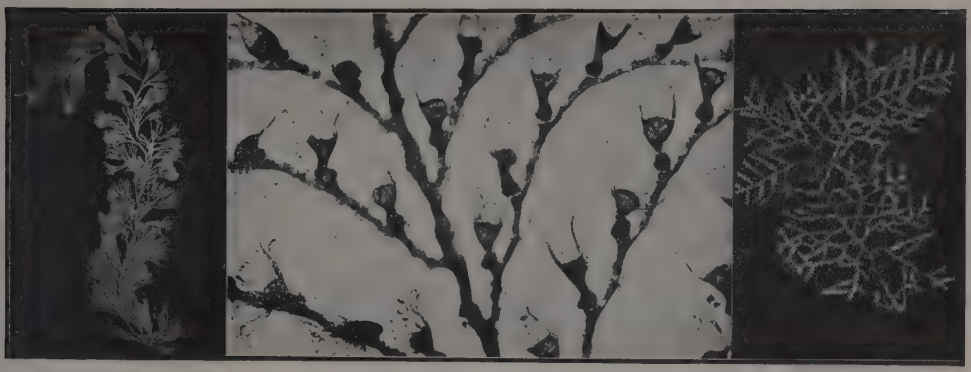
In a drop of sea water examined under a microscope fifty animalcules were found, in each square of the micrometer glass, or each eight hundred and fortieth of a square inch; and as the drop occupied a circle on a plate of glass containing 529 of these squares, there must have been in this single drop of water about 26,450 animalcules. In a gallon of water there would be more of these tiny living creatures than there are human beings on the globe. It gives a wonderful picture of the minuteness of creation, when we think of more than twenty-six thousand animals living, obtaining food, and moving perfectly at their ease, with plenty of room, in a drop of water. About one hundred and fifty millions of animalcules would have abundant room in a tumbler of water.

PROTOZOA

These creatures belong to what scientists call "protozoa," which means "first animals." They are usually classed as the simplest of all the groups into which the several hundred thousand different sorts of living animals are divided. But the more these tiny animals are studied the less simple they seem. Each small creature has a set of organs finely fitted to carry on the same kinds of work which the bodies of larger animals perform.

Many of them possess mouths. Often these "mouths" are funnel-shaped openings surrounded by short hairs called "cilia." The cilia, by moving back and forth, set up in the water a current which sweeps food into the opening. Food is digested in spaces, which look like little drops of water within the body. Structures that look like other water droplets gather waste materials and send them out of the body.

Each animal has some means of motion, although those that grow on stalks cannot move from place to place. Rows of cilia cover the bodies of some protozoa. These hairs act like oars and send the bodies so swiftly through the water that it is difficult to keep them in sight under the microscope.



COLONIES OF PLANTLIKE ANIMALS

After they have reached a certain size, most of the protozoa divide across the middle, so that two animals are formed, each of which is half the size of the original one. These two grow until each is as large as the one from which it was formed.

At times, instead of dividing across the middle, an animal will divide into several smaller animals. In some cases two of these very small animals unite, and the two grow into one new animal of the regular size.

The bodies of the protozoa are transparent and of all sorts of shapes. One of the commonest found in the potato infusion is the slipper animalcule, which you will easily recognize by its shape; another, the flower animalcule, is known by its bell-shape raised on a slender, more or less curled stem, a number bunched, as it were, in a colony. Then the night-glow, the Noctilucas, which makes the sea look like liquid fire on a dark night is another of the protozoa.

A PIECE OF CHALK

You have been acquainted with still other sorts of protozoa as long as you have used crayon; that is, if the crayon you used on your blackboard was old-fashioned and made of chalk.

One of the greatest of English scientists, Professor Huxley, made a piece of chalk the subject of a lecture so wonderful that everybody who loves the world about him should read it in "Lay Sermons," if he has not already done so.

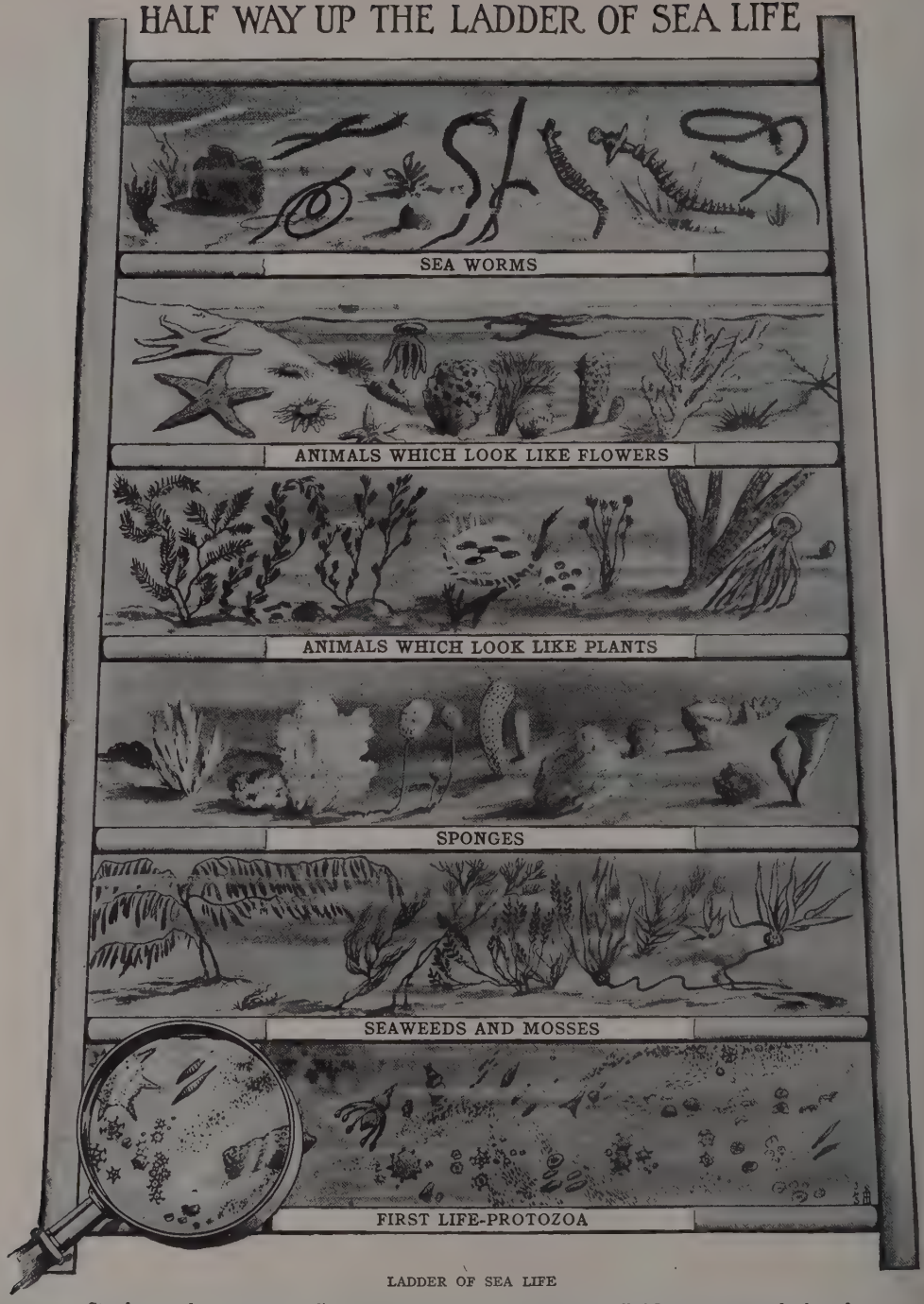
Professor Huxley told his listeners how, by powdering up a particle of chalk, and looking at it with a microscope, you could discover a whole new, ages-old world, of which you had known nothing before. This powdered-up chalk is nothing else than myriads of the skeletons that ages ago covered the bodies of the protozoa, called *Foraminiferæ*, meaning "pore-bearing," so called from the tiny holes in the shells through which the living creature puts out his "false" feet to enwrap his living food.

WHAT MARBLE IS MADE OF

Now, will you not feel better acquainted with *Foraminiferæ* when you learn that not only is chalk made up of these ancient shells, but that the bottom of the ocean depths is covered with them, that the pyramids of Egypt are made of them, hardened together into marble; that the marble of our buildings is nothing else than these same lowest of protozoans, the pore-bearers? Each tiny animal furnished its particle of the mass; race after race left its minute shells behind it; through ages the work went on to cover the ocean floor, to form the chalk cliffs that gave England, in the days of Cæsar, the name of Alba (white), to make the marble quarries that furnish that most beautiful city of Paris with its building material.

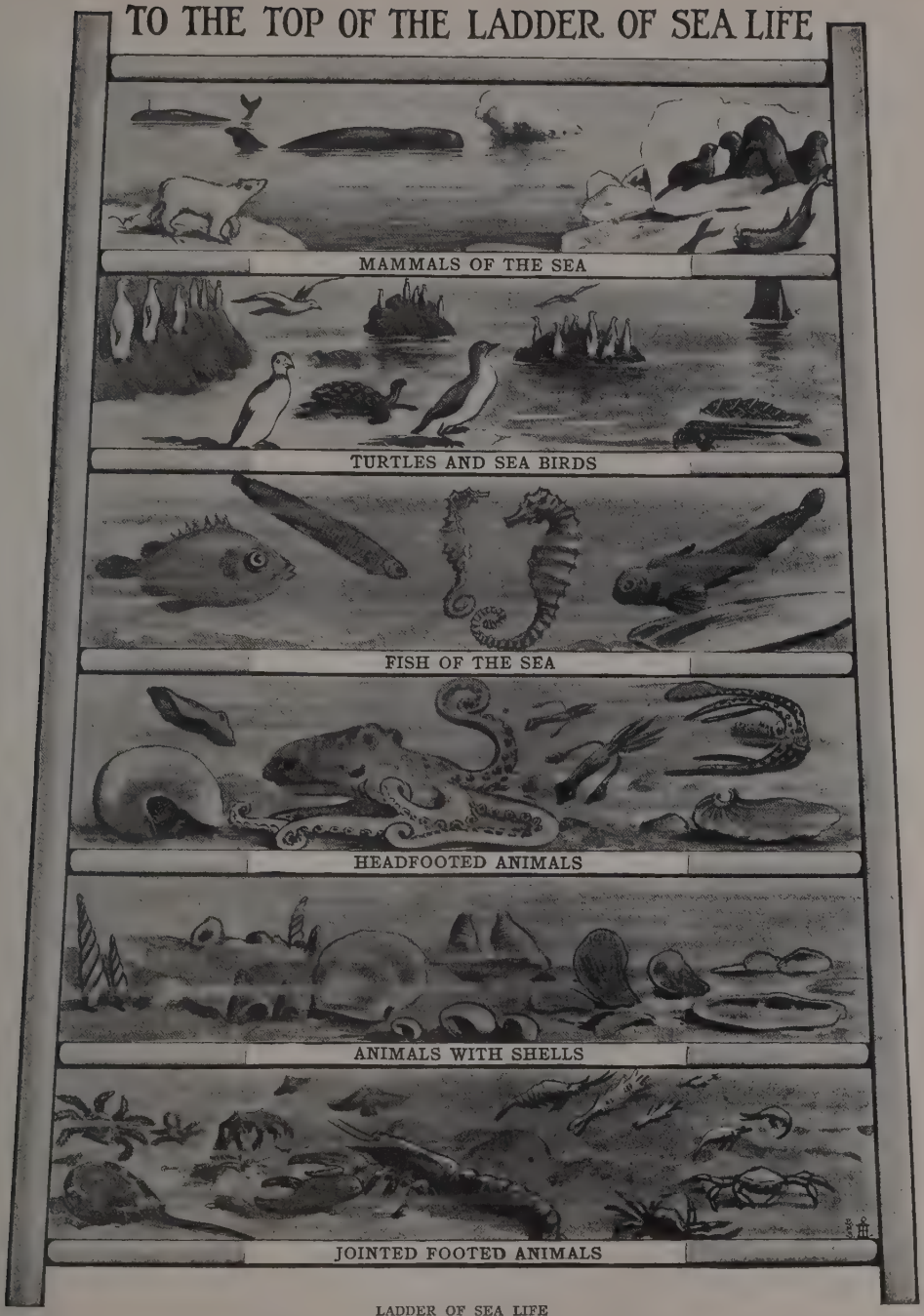
THE SIMPLEST PLANT FORMS

Side by side with these simplest of life's animal children, the protozoans, are the simplest



LADDER OF SEA LIFE

Step by step the sea creatures climb the ladder of life. Above the one-celled Protozoa, seen only through a magnifying glass, are the cell colonies of seaweeds and sponges. The next group are on the borderland between animals and plants. Then come starfish, jellyfish, and sea anemone, and the more highly organized sea worms, with rights and lefts.


TO THE TOP OF THE LADDER OF SEA LIFE
MAMMALS OF THE SEA
TURTLES AND SEA BIRDS
FISH OF THE SEA
HEADFOOTED ANIMALS
ANIMALS WITH SHELLS
JOINTED FOOTED ANIMALS

LADDER OF SEA LIFE

Now come crabs, lobsters, and shrimps, shell dwellers like the oyster and the clam, an odd group with the octopus and pearly nautilus, and at the top four classes of animals with backbones, the great army of fish, turtles and tortoises, birds of the sea, and the whale, dolphin, seal, and porpoise. Look for them in the story of each group.

forms of plant life. Most of them can be seen only with a microscope. The best known among them, however, are not microscopic. They are the sea mosses and seaweeds, which are found so commonly along the shores. Before you go on up the ladder of animal life, it will help you to become acquainted with their forms and ways.

HOW SEA FAMILIES ARE FOUND OUT

As you read this story of sea life, which seems to run along so smoothly, you must remember that it is a story which could not have been told fifty, thirty, twenty, or, in some parts, even ten years ago. It is as if all the members of a family, hundreds and thousands of them, had scattered to all parts of the world — and then someone went to work to find them out. Some of them would look alike; others might seem to look alike, but would prove not to belong to that family at all; and still others would be almost impossible to trace.

So some of the sea families were worked out on a plan which was not right until scientists could take their microscopes and study the tiny cells of which they are made up, and divide them in companies which were right, not because they looked alike on the outside only, but because they were made the same way. Watch the families as you go on, and see how very large and very small creatures prove to be of the same branch, and how each one has its own special mark by which we know it.

The order in which the story is told is the order in which creation climbs the ladder of life. We might study it on land, beginning with the simplest one-celled land creatures and working up to man. Here we are doing it in the sea, where some of the most beautiful and interesting lower forms of life are found. The story of life is the most wonderful story in the world. It begins in the drop of water, which seems to us lifeless, but has myriads of living creatures in it. It opens with one single cell. Watch, as you read of the sea families, to see how each gains something over the last, and climbs a little higher on the ladder of life. Every great class of the animal kingdom has its representatives in the ocean. Because in each class some forms are very simple, there is no place like the sea to study the beginnings of life.

A SINGULAR SEA PLANT

ALGÆ

WHAT kind of plant must it be that has neither leaves, stems, roots, nor flowers? Yet there are plants of which this is true, and if they were counted they might outnumber many better-known kinds. Some of these which have their life in water and are wholly fed by it are called "algæ." They are commonly known as "seaweeds," but algæ is their real name and it is pretty enough to be kept.

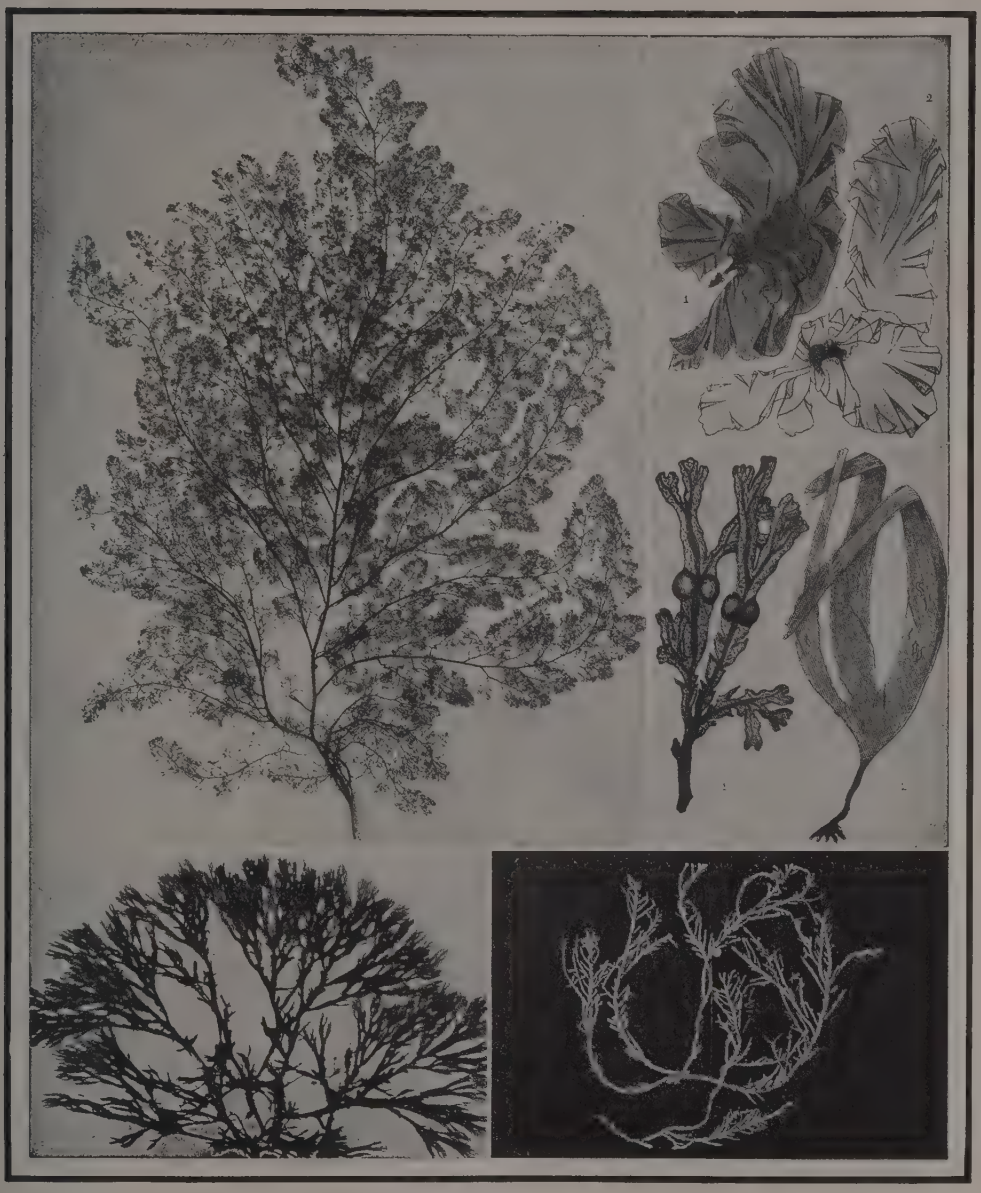
Algæ consist of cells, and it is the way these cells have of arranging themselves and of acting together which makes their story of such wonderful interest even to those who may never actually see them. Besides, these humble plants are of the greatest help in teaching things about life itself, such things as are not so plainly seen in higher plant forms. Do not forget, however, that while companies of the algæ reach gigantic size, they are made up of minute cells, and that when you study them you are wearing, or someone is wearing for you, the strongest of spectacles, the microscope.

THE GIVE AND TAKE OF LIFE

As water covers two-thirds of the whole surface of the earth, there is plenty of room for the mighty hosts of algæ needed to keep alive the tremendous number of sea creatures large and small which depend on them for food. Water has in it many elements that animals need, but they cannot take these directly from the water. Vegetable life feeds on these very elements, this inorganic matter, which water contains.

The word "inorganic," which you will constantly meet, means "without organs," and expresses the difference between a mineral or a stone or crystal, and a fish or dog or man. Your heart and lungs are "organs" of your body; the stone has nothing but its various chemical elements and is "inorganic."

Plants like algæ take this inorganic matter from water for their food, and change it to material which animal life needs, such as starch, albumen, and sugar. Then the animals of the sea feed on the plants and gain their required nourishment. The same thing takes place on



SEA MOSSES AND SEAWEEDS

Try to imagine these sea mosses in their original colors, red, purple, soft green, brown, and yellowish, floating on the water. The large one is a branching red variety; at its right are the green and purple lavers, their fronds broad and flat; the bladderwrack with its oval bladders which are filled with air and explode with a noise if you step on them. Below to the left is the tree-like red Delesseria, and to the right the deep purple coralline alga, which has the power of sucking out lime from sea water, as do the corals.

land with plants and animals, and keeps up what is called the "balance of life." Oxygen is needed by both plants and animals so that food may be used in their bodies for producing heat. Every plant and animal has some means of obtaining oxygen or, as we usually say, of breathing. In exchange for the oxygen which they breathe, the cells of all living things give out carbon dioxide.

When green plants are in the sunlight they use in making food the carbon dioxide which they give off in breathing. They also take greedily from the air carbon dioxide which animals breathe out. At the same time they set free a supply of oxygen. Some of this oxygen they use for breathing. The rest becomes part of the air and may be used by animals.

On land and in water this give and take is constantly going on between animals and green plants during the hours of sunlight.[1]

WHERE TO LOOK FOR ALGÆ

Seaweeds are studied best in two groupings. First, as to geography, there are kinds which are found along the Atlantic shores from polar regions as far south as Cape Cod; others from Cape Cod to Cape Hatteras, from Hatteras to Florida; and truly tropical ones from there to Florida Keys and the Gulf of Mexico. On the Pacific coast the divisions are also well marked. Another way to group them is to begin at the line of high water, and study first the seaweeds to be sought between lowest and highest tidemarks, then those between lowest tide and fifteen fathoms (ninety feet) depth, and lastly those between fifteen fathoms and fifty.

Taking the second grouping: the first condition is of plants exposed every twenty-four hours in turn to sun and air, and to water. To be alternately dried and wet every day does not harm them, because of the presence of a sticky substance like gelatine or glue, which these particular algæ cells produce as bees produce wax. Irish moss is a well-known seaweed which peasant people gather from rock-ribbed coasts. In fine bleached form it makes an excellent blancmange which is used as a food. In coarser form it is a food for cattle. All these rockweeds which are so easily obtained from the edges of the sea are useful, either as fertilizers for the land, or when burned and ground in great quantities to furnish soda, iodine, and bromine.

The beautiful red algæ, of which there are very many kinds, are an example of the second class, found at the lowest tide and a little way out to sea. The Red Sea is so named from the color the seaweed colony gives to it. These are the sea mosses which branch out in graceful shapes of every kind.

In the third class are the so-called coralline plants, though they are not corals. In place of the gelatine or glue of the high- and low-tide seaweeds, these have a secretion of lime which gives them more stable form. These deep-sea algæ help to make great deposits at the sea bottom. It is first an ooze in which creatures live, but it hardens in time into solid rock. The city of Richmond, Virginia, is built upon such a fossil bed, from twenty-five to eighty feet thick, which was part of a sometime teeming city of quite another kind of life from that which it now supports.

While each tiny alga cell is soft and nearly transparent, such a mass of it as makes a beautiful form and is named a sea moss may have the toughest kind of texture and be really highly colored. Seaweeds vary from being as thin as the lightest paper to being tough and leathery and almost as hard as wood. A great many are jellylike in their texture, hardly holding to form at all when out of water.

In color, seaweeds are often very striking. Whatever hue can be made by combining the three main colors — red, green, and brown — algæ seem to have either found out or stumbled upon in their beautiful soft tints.

One of the most interesting employments at the seashore is the mounting of seaweeds on drawing paper. This is a simple process, owing to the gelatine in them; and it makes often a dainty picture, besides showing the marvelous variety in form which different species display. This runs from the finest tracery of mere threads to flat masses called *fronds* — tubelike lengths which, while they do not perform the work of real stems, help to fasten the seaweed at one end either to a rock surface or to some plant, leaving the other parts free to wave or float in

[1] See "The Cycle of Life," Volume Ten, pages 46–49.

the water. A most curious little contrivance is found in some of the commonest seaweeds, by which air bladders are formed a little way apart in these fronds. It is partly by them that the plants float. When dried these beadlike balls explode with a great sound if stepped upon.

Lying between Cape Verde and the Canary Islands is a section of ocean which presents, as a ship sails into it, the appearance of a waving prairie reaching farther than the eye can reach, covered with a yellowish brown vegetation. Columbus was the first to report upon this great expanse of brown sea, as large as the continent of Europe. The name was given to it from its plant, *sargasso*, a form of gulf weed, and it is always known as the Sargasso Sea. The sailors took fright at its marvelous appearance, as day after day they sailed in it. To overcome the fear of dangerous shoals Columbus tried to sound it, but found its depth to be greater than his line of two hundred feet could fathom. The sargasso are roving plants, not fastened to any spot permanently.

SPONGES

WHY is it that, though long use will end in tearing a sponge to pieces, the pieces never wear out? If you take the tiniest particle you can pull off of a good soft sponge and put it under a lens, you will find it to be made up of an interlacing network of fibers of a material that in coarser sorts is much like the horn of our finger nails, in finer sorts like the best silk of the silkworm.

You probably long ago learned that sponges come from the Indian Ocean, the Red Sea, the coast of Florida, the Gulf of Mexico, and the Mediterranean, and are obtained by diving. Some are hollowed out like a cup, some branched like a shrub, others spread out like a fan and are of every color, from brilliant orange to dull brown.

If you judged from an assortment of sponges in their natural home in the Gulf of Mexico, where they top some rock, hide in some cave, or hang from some ledge, you would easily class them with the seaweeds. But you would be wrong, as all the world was wrong up to the time that scientists were able to study the sponge with the microscope.

EVERY SPONGE A COLONY

Since that time it has been found out that the sponge is made up of a great host of cells that are able to live together in a group by reason of certain sets of cells doing certain parts of the housekeeping and trusting other sets to do other parts. Water is constantly entering the interior of the sponge through hundreds of tiny openings on the surface. Some of the cells lining the interior passages have waving, hairlike lashes which move more strongly in one

THREE KINDS OF SPONGES

Shell attacked by a boring sponge; a branching sponge; a glass-rope sponge.

direction than in the other. These lashes keep the water moving through passages from the many small openings into a main central passage and out a larger opening at the end.

Sponges are found at all depths. Some grow so near the surface that they are uncovered at low tide. Others live in the dark, silent deeps.

The interior of a sponge is often teeming with small forms of different kinds of animals who find shelter from their enemies in this way. On the other hand, one small form of sponge, known as the Boring Sponge, finds protection by burrowing into the shell of the oyster. Some kinds of sponges grow only on the backs and legs of crabs. By this arrangement the crabs are screened from their enemies, and the sponges are constantly carried about to new sources of food supply.

To understand sponge development, it is necessary to start with a sponge-germ dropped from a colony. The sponge starts like one of the protozoa, as a single cell, only that when the cell divides, the two parts stay together instead of separating. These two divide and become four; the four, eight; eight, sixteen, thirty-two, and so on, until the bunch of cells withdraws to an outside crust, leaving a hollow in the center. These cells are all provided with lashes (cilia) which wave about and carry the developing sponge through the water. After a time one side of this outer crust bends in so as to form a double-walled cup, and the sponge settles down. Meanwhile the sponge has lengthened and narrowed until it is about the shape of a pussy-willow, a quarter of an inch long, with a small opening at its free end and fastened to a rock at its closed end, ready to finish the fancy interior details of its house at its leisure.

Now the cilia, which have been at work paddling the sponge along, can begin their lifework of gathering food, and so is built up the supporting framework of horny chitin, of lime spikes, called "spicules," or of flint spicules.

HOW SPONGES PROTECT THEMSELVES

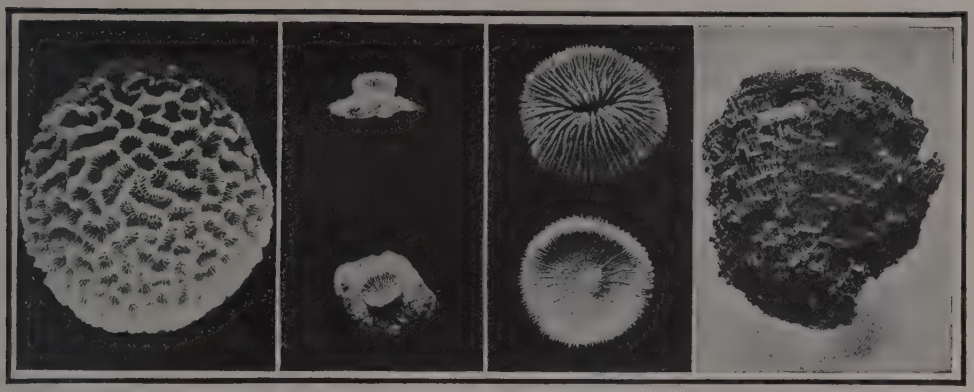
One of the strangest things you can ever see awaits you when you boil out a bit of one of the most primitive of the "calcareous" (lime spicule) sponges to see the marvelous framework built up, at once to support the slimy body of loose cells of which its owner is made and to make itself a disagreeable bite for its enemies. The sea is alive with animal life that "just loves" sponges without spikes. But sponges with spicules — points and darts and tridents, barbed and hooked and double-spiked — who wants a second mouthful? "Excuse *me*," says water flea. "Enough this time," says sea worm. "I never could eat spun finger-nails without a pain," says fairy shrimp.

So Nature has made a great success of her second trial of building up the animal kingdom; for until man, with hooks and hands, drags the sponges from their ocean homes, these humble denizens of the deep can hold their own against any enemy that would like a taste of their soft flesh.

Man has never been able to invent anything to take the place of the genuine sponge. Since the world has become certain that the "rubber sponge" won't do, sponge growers have begun to see that they can help Nature along in her work. So, taking advantage of the fact that a piece of sponge torn from the living colony will survive and increase, the sponge growers tried placing sponge-clippings on spindles set into a cement block and lowering them on to the ocean bottom. There they remain a year or two and increase in size sometimes at the rate of five times the cutting every six months.

Now that it is possible to grow the sponges away from the great depths that necessitate the expensive submarine armor, it is to be hoped that sponge culture will supply this great and permanent demand for the horny sponge's skeletons.

Gradually the primitive method of pushing off the sponges in water of wading depth by the toes; the method so long in use in Mediterranean waters of naked diving to a depth of fifty feet and remaining under as long a time as possible; and this later expensive method of the diving dress, where the diver goes to a depth of one hundred and fifty feet and stays for two hours — all these methods will be replaced when sponges are grown in sufficient abundance to supply the world at a depth that allows the gathering of those of known size by poles, from the side of a boat, assisted by a glass-bottomed bucket.



CORALS OF MANY SHAPES AND SIZES

ANIMALS WHICH LOOK LIKE PLANTS

LOOKING much more like plants than some of the sea plants themselves are the hydrozoa, many of which are colonies made up of a number of animals. The units of this life are simple polyps, hardly higher than the protozoa, but growing together in communities of wonderful beauty and symmetry.

A hydrozoan, like the sea fir, is a colony of thousands of these very minute polyps, in which each saclike body, while hungrily feeding itself, is helping to feed the whole. Joined to the common life by what we may call its foot, each single one can act independently as far as its own life goes. It is as if the whole community had what the name hydrozoa implies, a hundred heads. The word means hydra-like animals, and in legend you may find it in the old Greek story of Hydra with the hundred dreadful heads.

LIFE AROUND A CENTER

Each little head, a unit of life, appearing at the top of its little cup almost like an opening flower, shows under the microscope a circle of slender waving arms, or tentacles, which crown the polyps and surround the mouth. These waving tentacles every now and then seize upon specks of things floating in the water, and with a kind of lasso-like movement bring them back to the open mouth. Or some tiny microscopic creature, wriggling through the water on its own account, brushes against one of the flower-like heads and anon it is held fast by the lasso. It is seen to give a few convulsive struggles, but is soon stilled and quickly carried back by the long lasso. Why might it not have broken away from those soft, clinging threads?

LASSO THROWERS

The polyp tentacles are not so simple and harmless as they appear. It is not wholly a matter of strength. Each cell has coiled within it a fine, long, hollow thread, with several sharp barbs at its base. At the top of the cell is a hair trigger which keeps the coiled thread in place, and so sensitive is it that the slightest brush causes it to respond and release the coil. Is not this lasso throwing? The unfortunate victim by its struggles touches more of these cells, and more coils uncurl and dart out to grasp their prey. And as an added peril they are "stinging cells" as well, which touch the poor thing and poison it. This active quest for food shows the advance of the polyp over the seaweed. The actual mouth leads to the stomach, which communicates with the hollow tube that runs through the whole colony, supplying digested food for the common need in true co-operative fashion. Nature here supplies a fine illustration of economy in food supply.

Brehms Tierleben

SEA ANEMONES (natural size)

Various types of sea anemones, some with tentacles extended, others closed up. One (*Sagartia*) is perched upon the shell house of a hermit crab which benefits by the added protection of the anemone's stinging tentacles. (See "The Hermit Crab," page 232)

THE POLYP'S CHILDREN AND GRANDCHILDREN

The single polyps in each of the various tribes — sea firs, sea plumes, and moss animals — are so alike that they cannot be told apart. But among them, at certain times of the year, occur individuals without tentacles which are enclosed in transparent tubes. These long, slender animals give off buds which become the polyp's children. Since the tubes are transparent, the children inside them can be watched. They remain mere specks of things shaped like saucers until fully grown, when on some fine day a tube bursts and out they come, not nice sea-fir polyp children, but little saucer or umbrella-like jellyfishes! And these tiny jellyfishes never become larger, like the true jellyfish, nor yet do they become sea firs. But in due course of time, in which they have led a free, roving life, swimming by opening and shutting their umbrella bodies and capturing their food by waving the tentacles which fringe their edges, these free creatures, unlike the parent polyp, produce eggs, and from these come strange little oblong things, called *planulas*, that are no more like their parents than the jellylike parents were like their parent sea firs. These planulas are clothed with lashing hairs and so are able to swim freely. but after a while each settles down, firmly fixing one end to some suitable resting place, and in a short space of time there comes at the free end a tiny mouth, a circle of tentacles around it which can throw lassoes; and lo, the little being grows to be the exact image of the polyp from which its parent jellyfish came!

This is one of the most curious and wonderful processes in Nature. First, we have our pretty colony of feathery forms that can grow only by budding like a plant. From the bud spring jellyfish children, and from their eggs come planulas, the grandchildren of the feathery sea firs, which grow up into sea firs and begin the curious story over again.

THE GREAT JELLYFISHES

The rhythmic motion of the umbrella-shaped bodies of the great jellyfishes as they glide through the water in delicate ghostly forms is a sight to remember. At night many of them are lighted up by a strange glow of phosphorescence. Some grow to a great size, but are fragile things, and they live only from springtime to the coming of the first autumn gales. Planulas, or little children of jellyfishes, are safely anchored in the quieter, shallower waters, ready when spring returns to send forth a new brood. From a single little planula, by a division which is natural to it, may come several hundred jellyfishes. Is it not wonderful how many resources life has for maintaining itself?

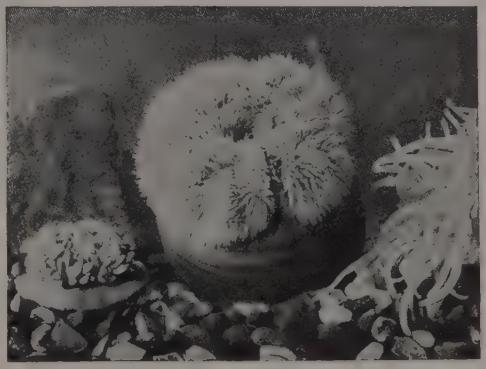
ANIMALS WHICH LOOK LIKE FLOWERS

WATCHING A POOL GARDEN

THE pool gardens are the most delightful parts of the seashore. Each is a little world, a hollow in the rock, where fine and beautiful seaweeds grow, quaint creatures live, and all sorts of unexpected treasures are to be found. Some of these pools are so deep that you can wade about in them, and the water is so clear that the little inhabitants can be watched as they dart in and out of the forests of seaweed. When the tide rolls in the pools are a part of the sea, but when it draws out they are left full. So the water is kept clear, and no one knows what newcomer may happen to stray in from the great sea.

THE SEA ANEMONE

The sea is full of "make believes," animals that look like ribbons, plants, and weeds.



BEADLET, DAHLIA, AND SNAKELOCK ANEMONES

TWO TYPES OF CORALS

The corals look more like plants than like animals.

Among these deceivers are the anemones of many different kinds, each with two names, with which we have little to do here, but also for the most part with a common name like *dahlia*, *daisy*, *cloak*, and *sand*, used with the family name anemone (pronounced an-em′-o-ne).

When the sea rolls over them they lift their pretty bright heads, rising on a sturdy trunk to four or five inches in height. Circles of dainty frills uncurl, white, cream, or salmon pink, around the circular top in which is the mouth. Below this is the open sac in which the creature digests its food. The tentacles around the mouth are sometimes like little fat fingers, sometimes like whiplashes or fine and featherlike flower petals. You would not think such pretty things could be harmful. A tiny baby fish knows better when they curl about it. But before even such an active little body can get away, down it goes into the mouth, stung by these nettlelike arms.

ANIMALS WHICH BUILD ISLANDS

It has been said that some of the polyps secrete lime in place of the tough gelatine. Among these are the true coral polyps, which when seen alive are fully as varied and interesting in their forms as the anemones.

Feeble as single coral builders (polyps) are, together they have built masses of limestone which are the foundation of islands, extending over a space five thousand miles long and fifteen hundred miles wide. The South Sea Islands, called Polynesia, are most of them coral islands. A coral island is encircled by a reef, or ring, of coral. Waves dash without ceasing against the reef, and a long line of foam sparkles in the sun. No rampart of mere rock could resist in this manner the action of the waves. It would be swept away in time and destroyed. Yet age after age the coral reef holds its place, a living barrier. Millions of little architects are always at work, or at hand

to repair an injury. Streams of fresh water that keep flowing from the island itself kill the first line of polyps and prevent the formation of a reef in front of them. The foundation of these islands may be of volcanic origin, and not at all the work of the coral polyps, which cannot live at great depths. Their work must have been begun where some portion of rock was covered only by a slight depth of water. Generations after generations of polyps pass away, and still the work goes on. It must stop, however, as soon as it reaches the surface, for the polyps cannot live out of the sea. At first there was only a rough ledge or platform, covered in patches with coral rock. As the tide ebbed and flowed upon it, seaweeds, shells, and sand were cast up which in time formed a soil on which seeds, no one knows from where, took root and so shrubs and trees at last appeared. Finally people arrived to make the island their home.[1]

SEA WORMS

ANIMALS WITH RIGHTS AND LEFTS

THE true student of nature, or biologist, finds worms to be among the most interesting of the lower orders of life. Some of the sea worms are even beautiful in form and coloring; and they are the first examples of several parts and ways which become the natural rule in higher forms. They are, for instance, the first creatures to carry a certain part of the body forward by the help of the other parts; the originators, we might say, of "going ahead." They are also the first to have parts that are alike set opposite each other along a line. This is called "bilateral symmetry." Consider what a great number of higher creatures have right and left sides matching each other, and think if this rise in life is not enough of an achievement to entitle the pioneers in such a plan to our respect.

There are four distinct classes, easily recalled as wheel, flat, round and ringed worms. Wheel worms are microscopic in size—just about ½ of an inch long. They make themselves fast by two hooks and have a "wheel" of cilia around the free end. The most common, called "moss animals," live mostly in colonies and look much like seaweed.

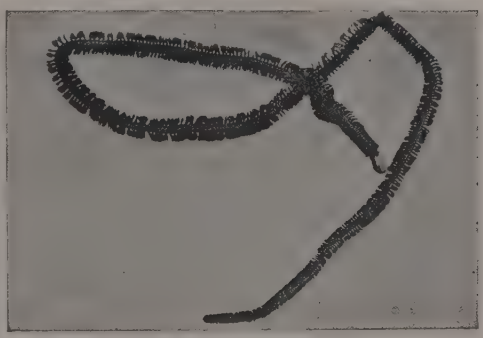
FLATWORMS, WITH A SHARP TONGUE

Coiled under a flat stone on a sandy shore will often be found a worm which looks like a ribbon wound up in a knot. This is one of the flatworms, or ribbon worms, which are of all lengths, from less than one inch to several feet. Placed in water the worm will uncoil. The blunt end is its head, and the mouth is on the under side of its body. From an opening above the mouth a fine thread can be shot out and drawn in with much force. This proboscis, or tongue, has often a sharp point and smaller barbs, so that it is quite a formidable weapon.

These worms are all greedy creatures, devouring anything living or dead which comes in their way. They are cannibals, too, and frequently devour each other. They have also

THE "RED CAT" WORM

A shore species often used by fishermen for bait.



THE PADDLE WORM

It propels itself by its many legs with a snaky movement.

[1] See pictures in Volume Ten, pages 232–233.

THE "WHITE CAT" WORM
This worm is nearly a foot long.

the power of re-growing a lost part, though while the head part will grow a new tail the other part lives awhile, but does not always gain a new head. Some large nemertines, however, seem to have a habit of breaking up into short lengths if irritated, and each length grows a head and tail and becomes a complete worm. A snapped-off proboscis is quickly replaced. Spiny parts of other creatures which the nemertines swallow are pushed out through the soft flesh without seeming to cause injury, as the parts quickly heal, showing no sign of the wound. Some of the nemertines and some of the flatworms, which are closely related to them, are very brightly colored.

As the name indicates, flatworms are thin. The under surface is quite different from the upper surface.

ROUND WORMS

Round worms vary in size from those that are microscopic to forms that are two feet in length. Some live free in fresh or salt water or in moist soil, but most are parasites in some animal or in man. One of them has given rise to the curious superstition that horsehairs become snakes. These "horsehair snakes" are round worms about the size of a coarse horsehair. They lay their eggs in water and the tiny worms which hatch from the eggs bore their way into some water insect. The insect is then eaten by some other animal. Finally the worm escapes from the animal's body, and it is at this time that it is called a horsehair snake.

RINGED BODIES

The highest class of worms are the ringed, or segment, worms. They are called *annelida*, which means ringed. Each ring has a separate set of organs. Some annelids have hardened outer skins; some have bristles; others have tentacles around the head and enclose themselves in tubes. The eye and ear are more highly developed in some annelids, and their nervous system has distinct centers, or *ganglia*. The aphrodite, sometimes called the sea mouse, is one of the most beautiful of worms. It is brightly iridescent, or rainbow-hued. The sea mouse lives below tidemark, but is found on the beach after storms.

The lugworms, which the fishermen dig for bait, are of dark brownish-green color and measure from five to ten inches in length. If you were to look at one of them you would see a series of sections or *segments*. At the head end, six of these carry a double row of fine bristles. Then come twelve or thirteen segments each bearing *gill tufts* and bristle-clad feet. The gill tufts are the worm's breathing apparatus. They are yellowish red, and look through the microscope like graceful boughs of a miniature shrub.

Because the lugworm's head is made in parts or segments, he can lengthen and shorten it like a telescope, making it either cone shaped or flat at will. He can draw it in and make it a boring tool which will open up a passage through the sand, and then enlarge it by

THE LUGWORM
It is from five to ten inches long, and tunnels into the sand for its home.

widening till the delicate gill tufts can be drawn through behind it without being injured. A great deal of sand is swallowed in the process, and when the food that is taken with it has been digested the sand is thrown out, making curious little mounds. If you know the ways of the interesting land cousin of these worms, you will recall how soil is made loose and fertile by passing through earthworm bodies in the same way.

The lugworm is like a mole in avoiding the light. It tunnels to eight or nine inches for its home. If you find one in the sand, it will make an interesting study.

The sand worm, or clam worm, is one of the annelid worms that lives in the sand or mud of the seashore. It builds burrows similar to those of the common earthworm, into which it can retreat at the first sign of danger. The burrows of the sand worm are sometimes two feet deep. Since they are at tide level, it seems as if the waves would constantly fill the burrows with the shifting sand or cause them to collapse. But the sand worm possesses a means of preventing such a disaster as the collapse of its home. With a more or less sticky secretion it binds together the grains of sand in its burrow so that the structure keeps its shape in spite of the action of the waves.

During the day the sand worm remains in its tube, but at night it stretches its body out of the opening of the burrow in search of food. At times it even leaves its burrow altogether. The sand worm is a relative of the earth worm, but it shows some interesting differences. It possesses two pairs of eyes and around its head are four pairs of tentacles which act as feelers. The projections from the body segments which serve as feet are longer than those in the earth worm, and they are fitted to serve as breathing organs as well as feet.

THE VARIFOOTED WORM

This extraordinary-looking worm becomes beautifully phosphorescent at night.

PHOSPHORESCENCE

Many of the sea worms become beautifully phosphorescent at night, shining with a wonderful blue or greenish radiance, constantly changing and so bright that if one or two are placed in a small glass tank filled with sea water, it is possible to see by their light the figures on a watch and tell the time. Looking down into the sea on a dark, still night, and watching these writhing phosphorescent lights, reminds one of the vision of Coleridge's Ancient Mariner:

"Beyond the shadow of the ship
I watched the water snakes,
They moved in tracks of shining white,
And when they reared the elfish light
Fell off in hoary flakes.

"Within the shadow of the ship
I watched their rich attire:
Blue, glossy green, and velvet black
They coiled and swam; and every track
Was a flash of golden fire."

STARFISH AND THEIR COUSINS

IN starfishes a great advance is made beyond anything which is seen in the lower subdivisions. They are the highest of the radiates, creatures whose parts go out from a center. All the plantlike colonies, the small jellyfishes, the sea anemones, and the sea fans, are radiates.

Starfishes belong to the Echinodermata, which is not a hard word when it is analyzed. It is from Greek words for "hedgehog" and "skin," and is given because the most striking thing about the creatures is the rough, spiny armor. There is quite a variety among echinoderms: the *crinoids*, or sea lilies, among the most common fossils, and different sorts of rayed starfish and brittle stars. The boxlike sea urchins and their distant relatives, the wormlike sea cucumbers, are the chief among them.

To understand the whole group of animals it will be well to become acquainted with the structure of one of them, and a starfish is a common form and is typical of all.

Almost everybody has seen starfishes, for when the life has gone out of them they can be kept as shells can. Seen as it lies upon the sand, its five arms stretched out, the starfish looks a helpless thing. You may turn it over and the most it will do will be to gather itself into a heap. It will not be very happy, but it will not try to get away till the tide rises. But you may put it in a little pool of water and learn how it crawls about. It moves in the direction of any one of its five arms, each of which has an eye at the end. On the under surface of each arm is a groove filled with small tubes, which are arranged in rows. When these tube feet are pressed against a surface, their ends act like tiny vacuum cups and hold firmly while the animal is pulled along. The skin is soft, and through it you can see the limy rods and plate which make its skeleton. Fleshy bumps all over the back have a skin so thin that the starfish breathes through them. Among the large spines of the back and along the under surface of the rays are tiny spines, each ending with a tinier pair of pincers. You see, the little creature has not only feet fitted for crawling along the floor of the sea or for climbing over rocks, and eyes to help it find its way about, but a most remarkable apparatus in the pincers with which among other things it keeps itself clean.

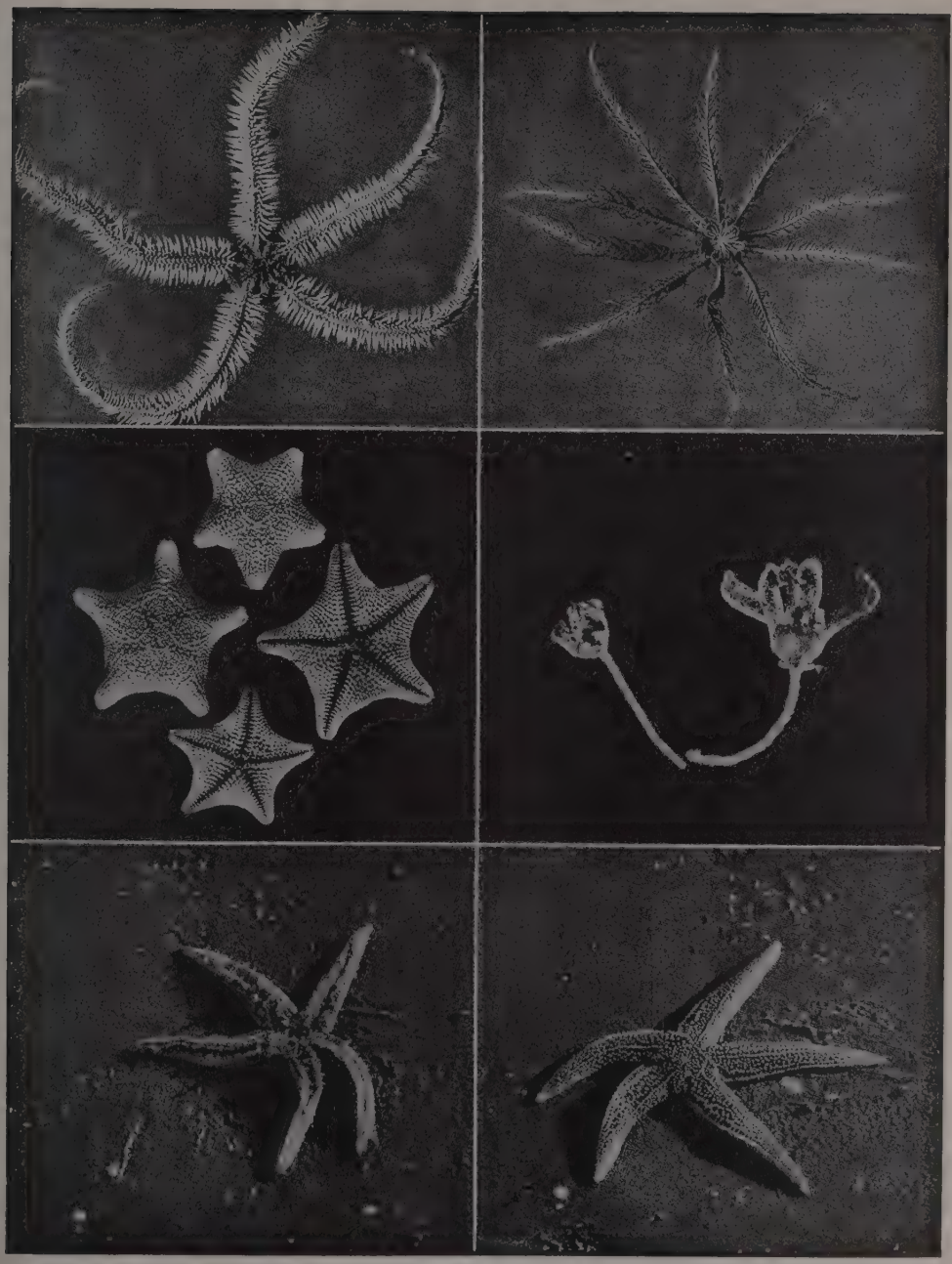
GROWING NEW LIMBS

It is now well known that starfishes, like many other creatures in the sea, have the wonderful power of growing new limbs to replace those that have been lost or injured. They are hungry, greedy creatures, and people who are watching their oyster beds know how skillfully starfishes can use their five arms in clasping an oyster so that they may eat the soft flesh within. The varieties of starfish are interesting, each for some new contrivance for the life the creature lives. The boxlike form of the sea urchin resembles a starfish with rays firmly joined around its soft, central body. An ugly-looking member of the family is called the "sea cucumber." Lobster fishers have to watch against its getting into their lobster pots, in which case the lobster itself stays out.

All these creatures begin life as odd little free swimmers, and go through many changes before they settle down. Twenty million eggs in a season sounds a big story. It tells, however, that other creatures of the sea depend upon them for food.

With the help you have from going thus far up the Nature line of more and more highly organized forms, the pictures of such species as you have not known will be more easily understood.

THE SEA CUCUMBER



STARFISH, OUR FAMILIAR ACQUAINTANCES ON THE BEACH

Above to the left the Brittle Star, to the right the full-grown Feather Star, and below it the Baby Feather Star, with next it the four plump Cushion Stars. The lower line shows the under and upper surfaces of a Starfish.

Brehms Tierleben

HERMIT CRABS

Crabs and their relatives change their skins as they grow. If they take up residence in a sea shell, as is the fixed custom of the hermit crabs, this house must also be changed as the animal grows larger. The hermit crab in the foreground has found a snail shell just a size larger than the too-tight one he has been living in. He is making the transfer as quickly as he can, for his soft body is unprotected meanwhile.

JOINTED-FOOTED ANIMALS

CRABS

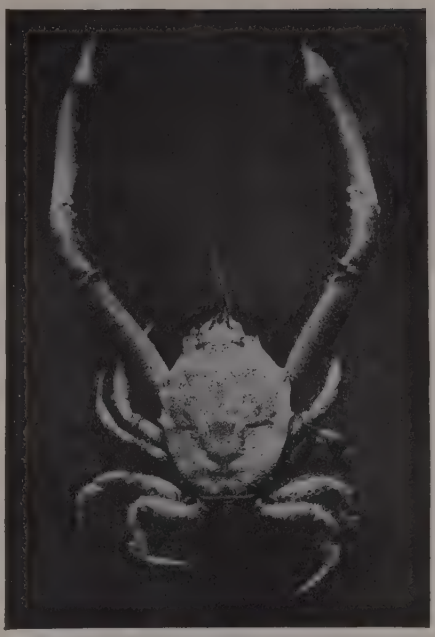
IT is interesting to know that of this subdivision of the creature world, by far the greater part live in the water. The crab is as well known as any of these *Crustacea*. What we call the shell of a crab is not really a shell at all. That is, it is not like the shell of an oyster or a periwinkle or a whelk. In these creatures the shell and the animal grow together, and it is never thrown off all through their lives. But the shell of the crab does not grow at all. It is only a crust of lime on the outside of the skin, which will not even stretch. The only way in which a crab can grow is by throwing off its "shell" to make room for larger size.

OUTGROWN HOMES

Once a year, therefore, until its full size is reached, every crab has to cast off its shelly covering and get a new one in its place. The going away and hiding among rocks or seaweeds is not from any sense of modesty but from the fear of its enemies. It is entirely helpless at this time, not even able to use its claws for defense.

The new covering of chitin, or outer covering, is secreted by the layer of skin cells which are left exposed when the old shell is cast off. This requires a little time, and it is during this interval that the animal grows.

Then the crab gets very restless, and wriggles about, turning and twisting from side to side and rubbing its legs against each other. It rests awhile and then begins to twist itself about again. This is repeated till the shell is no longer fastened to the body at all. A rent quite suddenly opens right across the back, and the crab leaps out of its old coat. For a little while the crab lies still and then begins to take on its proper size again. In less than twenty-four hours it is likely to be half as large again as before the change began, and in a couple of days a new shell will begin to form, and the animal will leave its retreat with a good new suit of stout armor to live in for another twelvemonth. The outgrown shells are left in perfect form as if ready for other creatures to use.



MASKED CRAB

HUNDREDS OF EYES

The eyes are one of the odd things about creatures like the crabs, for they see in a strange way. On each side of the head is a kind of stalk — you may have seen similar ones on the snail — and at the tip of each stalk is a small black spot. Under the microscope this spot is seen to be made up of hundreds and hundreds of very tiny eyes. A crab may have three or four thousand eyes. This sounds a very large number till you consider that the eyes cannot be turned from side to side or up and down. They are fixed and cannot be moved at all. Of these thousands of eyes some look upward, some downward, some backward, and some forward. Each eye acts like a telescope pointed in one way. It takes a great number to see in all directions.

All the Crustacea keep to the rule of a pair of jointed feet to each ring of the body; the changes are shown in the way these rings and limbs are used. The prawn, for example, uses his second pair of feet to catch his prey and hold

it, while the crab and lobster use the large, strong front ones. The shrimp can be told from the prawn by a kind of broad hand at the end of its head, with a saw-edged hook. When it is remembered that each of these changes in a creature stands for some new need met by a line of ancestors which has made it, the life stories gain in meaning, and the wonder grows as the knowledge increases.

HOW DO CRABS EAT AND WALK?

Another habit which seems quite intelligent is the way crabs eat. Give them a piece of fish and they will present a most comical appearance, going about eating it in a serious yet enjoyable way. With one claw they pull off a piece of flesh, and then pick at it with the other till a morsel is gained which is carried to the mouth and stuffed into it. They go on steadily till all the bone is picked clean.

In walking, the crab is awkward, as the fable tells us. The particular way crabs have of moving sidewise is the theme of an Æsop fable. A crab said to her son, "Why do you walk so one-sided, my child? It is far more becoming to go straightforward." The young crab replied, "Quite true, dear mother; and if you will show me the straight way, I will promise to walk in it." The mother tried in vain, and submitted without remonstrance to the reproof of her child.

PRAWNS, SHRIMPS, AND SANDHOPPERS

Down among the rocks and shallow pools when the tide is out there will generally be little shadowy forms darting about which, if they could be magnified to the size of a lobster, would look very much like it. These are the prawns and shrimps, which are difficult to tell apart save that the larger, rarer ones are likely to be prawns. In the South and on the California coast shrimp fishing is an important industry — for shrimps are a real luxury. Unlike some crabs, prawns and shrimps are free swimmers. When alive they have scarcely any color at all, and are nearly transparent, like the sand in which they can bury themselves in a moment.

The sandhopper may be seen at any time on a sandy beach. The nimbleness of these little creatures is almost beyond belief. The damp sand is honeycombed with them, and on the edge of the water when the tide is coming in they leap into the air to a height of twelve to eighteen inches. Sandhoppers have so many enemies that the wonder is that any of them are left alive. Long lines of birds may be seen gobbling up the active little creatures by thousands. But it is well they are not all eaten, for they are very useful in feeding upon decaying seaweed and other rubbish. All these are the cleanest of creatures themselves. You may often see prawn in an aquarium making their toilets. The front legs with stiff little hairs make a pair of brushes, and with them the prawn rubs itself over till perfectly clean. If any object should cling to its body, the strong little pincers on the second pair of legs will pull it off. The cleanly habits of the prawn are proverbial.

The temptation is to pick up sandhoppers and hold them in a handkerchief, but in a few minutes they would have nibbled so many little holes in the handkerchief that it would be spoiled for use. The sandhopper's skipping feat is performed by doubling its body up into a circle and then straightening it out with a sudden jerk.

THE LOBSTER

No one will deny that the lobster, the king of the tribe, is a most curiously formed creature. It is nearly black, and only when boiled does it become the vivid red we know it by. For its size it is monstrously strong, and so fierce are lobsters that they are quite well let alone, unless one knows the one or two places by which they may be safely held. Made to be symmetrical as to opposite parts, the great claws are an exception, for one of them is much larger than the other. This is not because the animal has at some time lost one through accident or battle and is growing a new one in its place, but because one is naturally bigger than the other; and the reason for this fact is that one is a weapon with which to fight, while the other is an anchor with which the lobster clings to the weeds that grow on the rocks on the shallow sea bottom. Fishermen sending lobsters to market in boxes have to put sticks into the fighting claws to prevent the ugly creatures from tearing off each other's claws and otherwise coming to harm.

BIG CRABS AND LITTLE CRABS

1. This is the sleeping crab, his arms tucked closely round him. 2. Crabs eating. 3. The hermit crab. 4. Crabs fighting. 5. The angular crab: see the sharp angles his claws make. 6. Two tiny broad-claw crabs. 7 and 8. Small and large spider crabs. Notice the different lengths of the claws.

THE LOBSTER, KING OF THE CRUSTACEA

HOW THE LOBSTER SWIMS

The swimming of the lobster is curious. The tail is made of broad plates, as you will see in the picture. These can be spread out much like the parts of a fan. They have a fringe growing all around them, and when a lobster swims he stretches his body straight out and then suddenly doubles it up. As he does so the plates of the tail spread out and form a broad and powerful oar, which strikes the water with such force as to drive the animal swiftly backward. With a single stroke the lobster will dart backward to a distance of twenty feet, and that so quickly that even the swiftest fishes could scarcely overtake him. But the lobster can also swim forward, and he does so, not by means of his tail, but by the five pairs of odd little organs under his abdomen which are called swimmerets. Each of these consists of two tiny paddles, and by waving these the lobster manages to travel along with some little speed. The swimmerets serve another purpose, for the mother lobster glues her eggs to the fringes of her swimmerets, where they stay till ready to be hatched. Baby lobsters swim about freely till an inch long, when they leave the surface waters and begin to live at the bottom, hiding in nooks and crannies and leading the same kind of life as their parents.

THE HERMIT CRAB

The hermit crab has been more written about than the rest on account of his borrowing a home instead of providing one for himself. He is usually found tucked comfortably into the large whelk shell, and if you disturb him he will retreat and close the opening with his big claw. If the shell is not too large, he will travel about dragging his home along with him. Sometimes a sea anemone is attached to the shell and carried to new feeding grounds. At the same time the stinging cells of the anemone protect the hermit from many kinds of fish which like to feed upon its long fat body, which is covered only by a soft skin. When the hermit crab is not protected by the empty shells which it finds, even its stout claws cannot defend it from enemies. From the time that the baby crab is a quarter of an inch in length on through its whole life, this crab is a house hunter, for his houses must match his growing size.

NUMBERING THE HOSTS

Shrimps, crabs, and lobsters multiply in such numbers that we need not be sorry that by far the greater part are cut off before they have time to grow up. A female crab has been known to carry at one time over twenty thousand eggs on the under side of her triangular tail, and some of the shrimps are not far behind. You can easily see that if all the babies that hatch were to live and grow up, there would soon be no room left for any other creatures of the sea. It is one of Nature's laws in both the plant and animal world that where the struggle for life is keen in the early stages there shall be a great number of seed and young.

BARNACLES ON SHELL STALKED BARNACLES BABY SQUID ATLANTIC SQUID

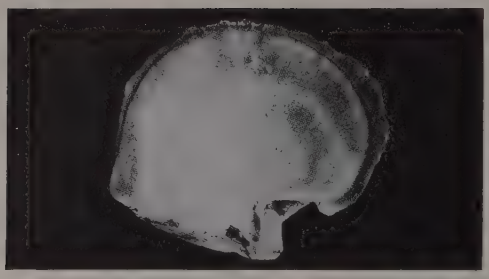
INDIVIDUAL WAYS

If you wish to see how particular crabs take each its own way, turn loose again a dozen or so which have been caught and see what happens. One or two will tumble over and lie quite motionless, as if they were dead. One scuttles away as quickly as its legs will carry it. One will be brandishing its claws in a very ugly way, ready to do battle with all comers. Some will stay still but will bubble and foam. Those that shammed death will have nearly buried themselves from view in the sand. So each takes its own method to try to get away from us. The crab mothers, if they were there and could talk our language, might say it shows how intelligent they are!

ACORN BARNACLES

A very remarkable little body lives in what we, thinking only of its shell, call a *barnacle.* You have seen rocks, wooden piles, waterlogged boats, and anything on the edge of the sea that will give them footing fairly covered with them. Most likely what you have seen are the acorn barnacles. They look like little molluscs but are much more closely related to the shrimps and prawns.

The top of the acorn-shaped shell has four little pieces which fit tightly together. The four parts make a trap door which can be opened and closed at will. While you watch, one may open suddenly and a tiny tuft of what looks like feathers be thrust out; then they are drawn back and the trap door is suddenly closed. The tuft is not feathery, however. What you see are the slender hairy legs of the little soft barnacle, which seizes its food and kicks it down into its mouth. There are six pairs of these pretty curved legs, and as they are clothed with hairs they sweep through the water like a net. From the baby stage, barnacles go through extraordinary changes and have two names, before they are full barnacles. When this time comes they settle down for life, fastening themselves with cement stuff from glands on the feelers around the mouth, and from this time on remain standing on their heads! Many a ship has had to be put into dry dock to have its sides scraped clean of the regular "forest of long gristly stalks" which in a long voyage come to hinder its progress through the water.



MOLLUSCA

MANTLE-COVERED ANIMALS

THE next great subdivision of the animal world makes a long step from the prickly skinned creatures which without exception must live either wholly in the sea, or else be safely near it during the ebb of the tide. These mantle-covered animals are the *Mollusca*. The name is from a Latin word, *mollis*, "soft." The name is well chosen, for it is true that while many of them might as well be called hard, not all the Mollusca have a hard shell, while they all do have soft bodies. It is this soft body that calls for the shell to protect it. In a great number of the most advanced forms, special weapons of defense have done away with the need of a heavy shell, just as a man with a rifle would not be induced to burden himself with a coat of mail. But all the Mollusca show signs in their growth from babyhood of having been related to forms that had protecting shells. Millions of shells preserved in all parts of the world, not to say countless multitudes which have been crushed and broken, have once been the home of a living animal which was born wrapped in a mantle.

THE MAKING OF A SHELL

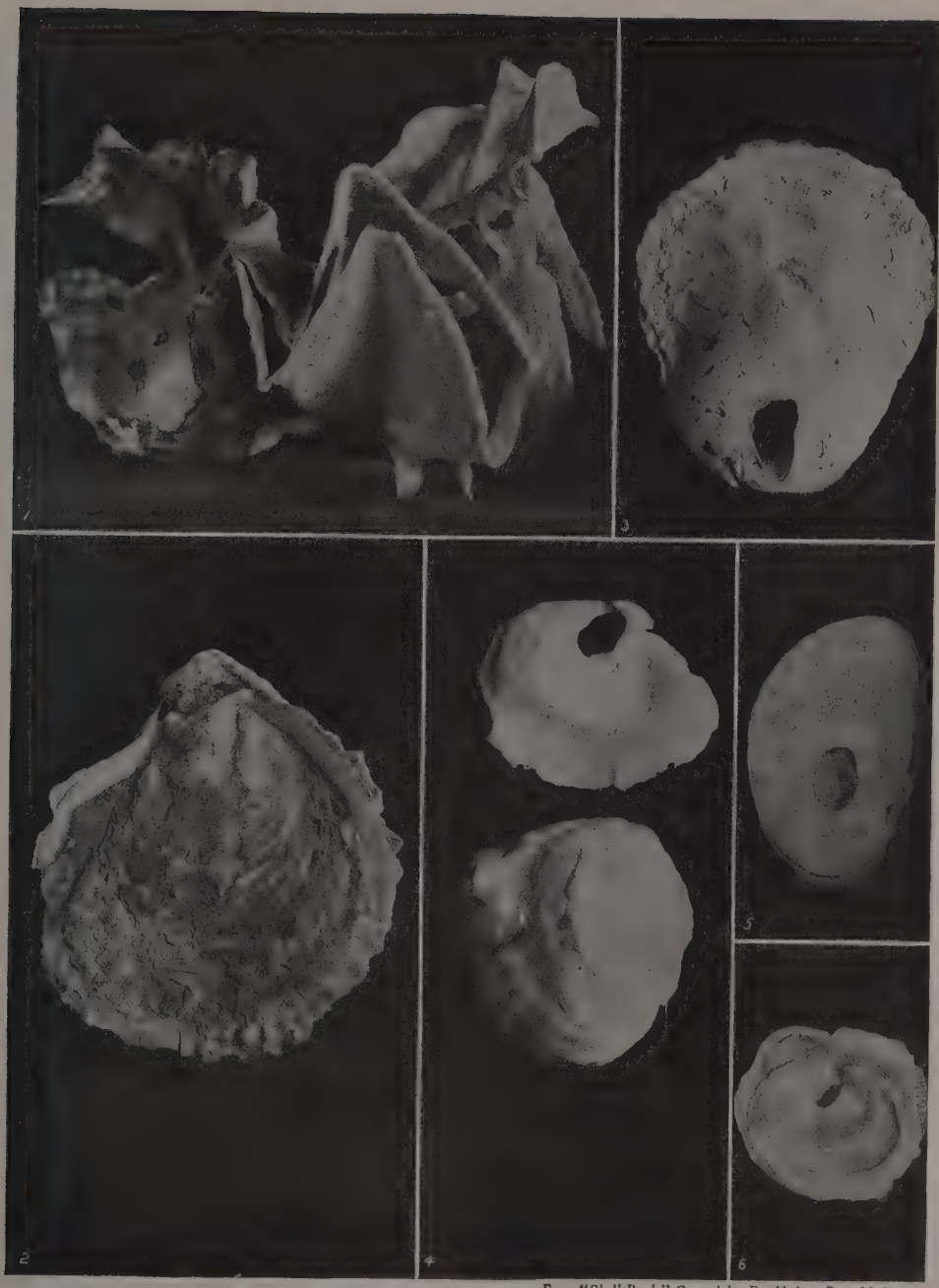
The wonder-working mantle which life has given to these soft-bodied Mollusca may easily be seen in any common shell-dwelling animal such as the oyster or the periwinkle. These two are types of two kinds of shell making. When an oyster is opened two transparent flaps appear, with thickened edges, one above and the other below the oyster. These, where they touch, enclose the animal between them. In the periwinkle the mantle is all in one piece, and is a transparent tube out of which the soft creature pokes its head and a crumpled foot which closes the lid.

HOW THE PERIWINKLE GOES TO WORK

When the young periwinkle was not bigger than the head of a pin and his shell looked like a transparent bead, he began to provide for growing larger and stronger. He stretched out his mantle till it reached over the edge of the shell and began giving out a thin film in which were grains of lime which had been passed into its mantle from its body. This film clinging to the inside and stretching over the edge made a new layer and a new rim to the mouth. The rim was colored by little cells of dark pigment, or dye, stored in the border of the mantle. The shell was now a little larger and a little thicker, and the mantle was drawn in till a more roomy house was needed for a child who, being alive, could not help growing. So the building went on getting enlarged as was needed, the lines round and round it marking the rims which had each in turn been its mouth. The enlargements can be counted in many of the kinds of shells. In this way not only the periwinkle but all the Mollusca build up their strong castles for homes and for defense.

AN OYSTER AND ITS SHELL

In the oyster each half of the mantle lays down its own separate valve, as all the Mollusca do which have no separate heads. These grow two-valved shells (*bivalves*), while those like the periwinkles, snails, and whelks, which have their heads and mantles all in one piece, are *univalves*. So each shell is a life story. The mantle's use is to make the shell, and the shell's use is to protect the soft form within, and each different sort of shell tells a different sort of story. The shells stand open naturally because they have an elastic cushion fixed within the hinge which acts like the spring of a jack-in-the-box to drive them up unless it is pulled down by a strong muscle, one end of which is fastened to the upper and the other to



From "Shell Book," Copyright Doubleday, Page & Co.

SHELLS OR "VALVES" OF MOLLUSCA

Each half-shell of an oyster is called a valve, from the Latin word *valva* meaning the leaf of a door.

the under valve. When danger is near the oyster or clam can pull its shell together with a snap. If you could watch the oyster alive you would see that all the water passing over the transparent frills of four striped bands which make the gills, flows towards an opening in the right-hand corner. This is the mouth. And under the microscope you would see a whole forest of lashes or tentacles such as you are familiar with in lower forms. By this stream the panting oyster not only gets its breath, but also a host of helpless microscopic plants and animals which are drawn in and swallowed.

HEADFOOTED ANIMALS

AROUND the heads of the molluscs of this class are tentacles which are really part of the foot. For this reason the animals are called Cephalopods, which means headfooted. Animals to which this name is applied include the squid, the octopus, the cuttlefish, and the nautilus. Only the nautilus has its body covered by a shell, although some of the others have shells covering part of the body, or sometimes located inside the body.

Naked soft-bodied animals are tempting morsels of food. The tentacles of the Cephalopods are their only means of defense as well as their means of capturing prey. Cuttlefish and squids have ten tentacles, or "arms," and the octopus has eight. The nautilus possesses more than any of the others. The bodies of the squid and the cuttlefish are long and cylindrical, while the body of the octopus is shorter and broader. All three of these animals have well developed heads with the eyes large and staring, like those of a fish. The mouths have hard jaws which soon end the lives of the animals that are unfortunate enough to be captured.

The tentacles and the organs of the head are the only parts of the body that are not covered by the mantle. The sac of the mantle completely surrounds the other organs except for two openings near the neck. One of these is funnel-shaped. Through it water leaves the mantle cavity, carrying waste materials from the body. Through the other opening, water enters carrying oxygen for breathing. Breathing is by means of gills which are along the sides of the mantle cavity.

HOW THE CREATURES SWIM

Nothing like real swimming, in long distances, belongs to the cuttlefish tribes, yet they can make quick progress in the water. A very tiny squid can leap many feet above the water. Squids have often been seen on a ship's deck. When a cuttlefish needs to hasten it can send out a jet of water that will hurl it backward with force and speed. A broadening of the body into something like fins helps the creature to swim forward. Where there are ten tentacles or arms, one pair is much longer than the rest, and these are used in taking hold. They are also useful when the creature walks on them, head downward on the floor of the sea, or when it swims backward, perhaps trying to escape the sperm-whale, its most deadly foe. Could anything be more curious than the structure of these strange animals?

What makes the arms of the octopus and its relations so deadly in their grip is that hundreds

DEVIL FISH

THE BLENNY

A little fish that can live two or three hours out of water.

AN OCTOPUS AT REST

Notice how he coils himself up in a small space.

of little suckers are all over the under side of them, and each of these works like an air pump wherever it lays hold. Each sucker is a cup with a muscular rim; and a vacuum is made inside it, so that the hold of these cups is amazing.

THE OCTOPUS

The common octopus does not grow to a great size, but a shuddering feeling comes over anyone who sees one in action. While its normal color is light brown splashed with reddish spots, it has the remarkable power of changing its color as it moves about. By taking on the color of its surroundings it escapes the notice of its enemies. When resting on the floor of the sea, with its eight whiplike, clinging tentacles peaceably curled and tucked away, it has been described as looking like a blob of jelly. From this creature, no larger than a football, arms shoot out, at the slightest touch, to the length of three or four feet.

THE DEVILFISH

Although the octopus is smaller than the largest squids it has long been known as the devilfish, and many tales have been told of its attacks on divers and swimmers. No doubt, these tales have been much exaggerated. If possible, an octopus will escape from a man and when captured, it struggles violently to get away. If it is one of the larger forms of octopus and the tentacles grasp some part of the man's body, the results may be painful. The smaller forms, even those with arms a foot long, can do no more damage than to squeeze the hand or arm.

The octopus, like the squid and the cuttlefish, possesses an ink sac. In moments of danger some of this ink is squirted into the water through the funnel which opens from the mantle cavity. In this way, a dark-colored screen is made to order, and under the protection of the screen, the animal escapes.[1]

The octopus often builds a shelter of stones. After it has been out in search of food it returns to this shelter. Sometimes it will leave the water to follow a crab over the rocks. Of course, it uses its "arms" for "feet" when it does this, and it often travels in the same way under water. When it swims, it moves a broad membrane between the lower parts of the tentacles. It can also shoot jets of water from its funnel, as the squids and cuttlefish do.

With the cuttlefish is associated the shell known as "cuttle bone," used for polishing powder; and with the octopus, the squirting out of the inky fluid, sepia, which fouls and darkens the water under cover of which the creature makes a retreat from enemies. These are articles of commerce.

COMMON SQUIDS

What are called squids are very abundant all along the New England shores as far north as

[1] See picture, Volume Ten, page 177.

CUTTLEFISH SWIMMING (above); ARGONAUT AND PEARLY NAUTILUS (below)

Newfoundland Banks. Fishermen use them for bait. That cod and mackerel are fond of them is shown in a story of a certain mackerel — not, however, on the New England coast — weighing four pounds having been opened, and twenty-four squid found in its maw. As it was in the act of getting one more which cost it its life, the fondness of fish for squids may be accepted as true. Where there are shoals of such fish as cod, the water is thick with the smaller kinds of squid.

GIANTS

Cephalopods range in size from the tiny loligo, two inches in length, to the giant squid, which grows to a length of fifty feet, and is the largest living animal known not possessing a backbone. They have been seen of the size of the cachalot, or sperm whale. The range is through the whole ocean world and seas of all climates, from the Arctic regions to the hottest climes, although those of greatest size are in deep tropic seas. And they are in general sluggish creatures, though capable of great exertion. The cachalot is probably the only animal that attacks the giant squid. Smaller creatures, like the large fishes, brush against a waving tentacle and find themselves held tightly, surrounded by sepia-colored water, and swiftly drawn down into the open chasm of the creature's mouth.

WHAT FEEDS THE MONSTER?

What vast amounts an animal must eat to support such amazing size! How does he forage for it? For the most part just as a huge spider does, waiting for his prey to come to him, his huge eyes watching, and the great chasm of his mouth wide open, the parrotlike jaws clashing on the victim as it passes into it. All that he needs must come to him, and as Mr. Frank Bullen has said, what an all it must be! Digestion is very rapid even in the smaller species, and the food is quickly dissolved, so that a creature so vast must be always calling for more.

VERY OLD STORIES

When we consider what accounts have been believed of the sea serpent, it is not strange that equally exciting tales are told of encounters with these seemingly fabulous monsters. One of the oldest of these goes as far back as the time of Pliny and Aristotle. It sounds incredible, and is no doubt an account in which imagination has played a great part.

While Pliny was Spanish consul, he tells us one of these creatures had the habit of coming ashore at night and plundering the salt-fish warehouses. It came once too many times and was slain. Seeing it, Pliny made it the occasion for a joke with his friend Lucullus in Sicily. He caused the head to be cut off and sent in a cask, which must have been larger than a sugar hogshead, to grace one of his celebrated banquets. The arms, he said, were thirty feet long and the sucker vacuum cups big enough to hold four or five gallons.

THE PEARLY AND THE PAPER NAUTILUS

One of the most delicate and beautiful treasures of the sea is the shell of the pearly nautilus. There are only a few forms left in existence, but fossil remains show that they were once more numerous. A notable thing about the nautilus is that it is one of the few species of the cephalopods that has a shell. Some people give the name "paper nautilus" to the argonaut, which also has a coiled shell. But the argonaut is really more like the octopus than it is like the nautilus. Stories of the argonaut as a kind of fairy craft are pretty to read, but, like other cherished stories told before science called for close observation and strict truth telling, they have to be given up for what is really the better story of how the argonaut makes the shell for a lovely cradle for her eggs.

Aristotle described the argonaut as holding up its spread-out arms like miniature sails to catch the breeze, while the rest of the long, slender tentacles made oars of themselves to carry them through the water.

Byron wrote of

"The tender nautilus who steers his prow,
The sea-born sailor of his shell canoe."

Pope tells us to

"Learn of the little nautilus to sail,
Spread the thin oar, and catch the driving gale."

And better than any is the poem by Oliver Wendell Holmes, "The Chambered Nautilus."

THE CHAMBERED NAUTILUS

BY OLIVER WENDELL HOLMES

This is the ship of pearl, which, poets feign,
Sails the unshadowed main, —
The venturous bark that flings
On the sweet summer wind its purpled wings
In gulfs enchanted, where the Siren sings,
And coral reefs lie bare,
Where the cold sea-maids rise to sun their streaming hair.

Its webs of living gauze no more unfurl;
Wrecked is the ship of pearl!
And every chambered cell,
Where its dim dreaming life was wont to dwell,
As the frail tenant shaped his growing shell,
Before thee lies revealed, —
Its irised ceiling rent, its sunless crypt unsealed!

Year after year beheld the silent toil
That spread his lustrous coil;
Still, as the spiral grew,
He left the past year's dwelling for the new,
Stole with soft step its shining archway through,
Built up its idle door,
Stretched in his last-found home, and knew the old no more.

Thanks for the heavenly message brought by thee,
Child of the wandering sea,
Cast from her lap, forlorn!
From thy dead lips a clearer note is born
Than ever Triton blew from wreathed horn!
While on mine ear it rings,
Through the deep caves of thought I hear a voice that sings: —

Build thee more stately mansions, O my soul,
As the swift seasons roll!
Leave thy low-vaulted past!
Let each new temple, nobler than the last,
Shut thee from heaven with a dome more vast,
Till thou at length art free,
Leaving thine outgrown shell by life's unresting sea

FISHES PHOTOGRAPHED BY MAN ON SEA BOTTOM

Photos by W. H. Longley

FISHES IN SCHOOLS AS THEY PASSED BY

Above: "Porkfish schooling about a coral head. These fishes feed almost wholly by night. They are about six inches long, as are also the piercing spines of the sea urchins sheltered in the rock crevices beneath them." Below: "Yellow goatfishes and yellow grunts schooling together about corals." For the story of these photographs, see Volume X, page 90.

THE FISH

BEGINNINGS are always interesting on account of that to which they may lead. The fish is the pioneer of the backboned animals. The secret of their power to rise was the backbone, or skeleton. The parts of a skeleton grow out from a jointed backbone, and the separate parts of the backbone are called vertebræ. A hollow tube is formed by a ring in each vertebra, and in the tube is a cord of nervous matter called the "spinal cord." At the head of the backbone the bony substance forms a strong case or box, and holds a larger mass of nervous matter called the brain.

Animals having vertebræ are called *vertebrates*. Those not having vertebræ are *invertebrates*. Up to the present time, we have been studying the invertebrates. Let us learn something about the higher animals which have backbones, the vertebrates.

ANIMALS WITH SKELETONS

The backboned animals are the only ones in life's great hosts that have inside their bodies living skeletons which can grow with their growth. This means strength, symmetry, beauty, and wider activity. The frame or support is not a thing apart from its life, a casing, or even a jointed armor of dead, hard matter, but a part of the life itself. Perfect skeletons did not seem to come all at once and ready made. A little two-inch-long creature still found on our shores shows what the beginnings may have been. This creature, called the lancelet, is interesting because it seems to have vertebræ in the making. With several other sea and shore animals which have similar structure, it is classed between the invertebrates and the fish. The bones of a very young child are soft, but those of the little lancelet stay soft. It is a half-transparent creature, and only by an open mouth can you place its head. Two little spots prove to be feeble eyes, and one tiny pit with a nerve running from it has the power of smell. A flap on its back and tail are all it can boast as fins, and only by a throb in the veins can you know how the blood is sent along, for it has no heart. It is only by courtesy that it can be said to have a backbone, but it has tougher cartilage along the line where the bone should be and above this line another rod which does duty for a spinal cord. It is not at all certain that this is the farthest back ancestor of all fishes and so of all vertebrates. It may be a degraded form of what was once a nobler type.

Some of the true fish have skeletons which never harden into bone. The substance of which the skeleton is made is called "cartilage," or gristle. It is a firm, tough substance which can be cut with a knife, and is the material from which the bone of bony animals usually forms. These gristly skeleton fishes keep on growing for a long time, and so come to a very great size. Few fishes fail to be cut off before they would come to a natural death, it is thought, and so the lifetime is a matter of doubt, but Pliny, whose story of the octopus is given, reports the life of a pike in which a ring had been put as being over two hundred years. And many report fishes known to have lived a century. It has been estimated that the offspring of a single herring, if allowed to multiply unchecked for thirty years, would not only meet every demand the world over, but become inconveniently numerous. Similar prophecy might be made for the cod, mackerel, and other fish families. The actual life, however, is probably very short.

SHARKS AND RAYS

While you are upon fishes whose cartilage does duty for bone, you should meet one of the powerful specimens. The shark possesses no true bones. Sharks and rays are dreaded monsters of the deep. One of the rays, from having its side fins spread out like fans, suggests wings and is called the angel fish, but there is nothing angelic about any of these voracious gluttons of the sea. By a singular contrast in names the devil fish also belongs to the same class. They all have a bad name among fishermen.

THE STURGEON

Sturgeon have the same soft skeleton. Some of them grow to a great size, twenty feet in length, and often weigh two thousand pounds. Spending so much time in rivers, where they

go to spawn, they are often counted among fresh-water fish. The mass of eggs called the *roe*, and containing hundreds of millions of eggs, weighs a fourth as much as the whole body, and is the chief value of the fish. Cleansing, drying, salting, and packing sturgeon roe is a considerable industry. In spite of its great amount of fat, sturgeon flesh is an article of food. Those which were caught in the Hudson River used to go under the name of "Albany beef," because they were shown in the markets of that city. Sturgeon was thought to be a sumptuous fish among the ancient Romans. The *caviar* we eat is made from sturgeon roe.

ELECTRIC FISHES

Another of the gristly-skeleton fish has cells at each side of the head which can give an electric shock. It is the electric ray. It is not so powerful as the electric eel, yet can benumb the arm of a person touching it. The ray fitted to give the most powerful shock is the torpedo-ray. Its electric organs are large masses, and it seems able to give shocks at will. By this means it can keep its enemies at a safe distance and can kill or paralyze its prey.

TRUE FISHES

Coming now to what answers to our idea of what a fish is, it is astonishing how little is known, by people in general, of fish life. It is not too much to say that, so far as man can interpret it, fishes have the merriest and most active life of any of the creatures, unless it be some of the insects. They are wise and wary, social for the most part, graceful and alert in their motions, and when seen in the water are beautiful in color. There are places where they can be seen to best advantage. Best known of these, perhaps, are the shores of Bermuda and the Barbadoes, where they are the delight of tourists. But if you will go out in a boat and anchor in any still sea that has a clean sandy bottom, more specimens will reward your watching than you are likely to meet of birds even in the heart of the woods. Perhaps you can get some specimens in your crab-net and take them home for further study in your aquarium. (See the Nature Student's Aquarium, Volume Three, page 373.)

FISH SHAPE

Long, slender, flatter a little at the sides, tapering at one or both ends, might describe a boat, but it is also our common idea of a fish. In other words, it is a shape which is splendidly adapted for cleaving its way through water. Although this is the general fish shape, the different kinds of fishes show almost numberless variations. The body may be cylindrical, as in an eel, or almost ball-shaped, as in the sunfish. It may be needle-shaped or ribbon-shaped. Some fish are flattened from above downward instead of from side to side. Fins vary in size, shape and arrangement. Heads of all sorts of shapes are found. Sometimes these variations of the fish bodies produce results that appear grotesque to us, but they furnish the fish with just the right aids for living under the conditions of its environment.

THE TAIL AS A PADDLE

Moving from side to side with quick, strong strokes, the tail of the fish acts as a paddle does in a boat. It is also used as a rudder in directing the course. Different forms and movements belong to different fishes according as they keep mostly to one level in the sea, as many of them do, or rise to the surface and go back again to deep water. These things show in the shape and set of the tail.

HOW THE FINS HELP

The fins keep the fish balanced in the water and help to steer its course. Big, strong fins belong to such fishes as must breast the strong waves of stormy seas; while some whose lives are spent in calm, quiet waters, gliding gently about or resting on the floor of the sea, have fins which are soft and small. After a little observing you should be able to tell this part of a fish's story by the kind of fins it has. Agassiz, who was one of the first naturalists to teach about fishes, could construct in his mind and give the right name to a fish from seeing certain bones.

Just below the backbone in most fish is an air bladder. The bladder is small in fish that live at great depths but large in those that live

nearer the surface and move from one depth to another. In some very ancient fishes the air bladder is connected by a duct with the throat, and aids in breathing. In most fish it merely serves to make the body more buoyant and helps it to keep afloat. Gases enter and leave the air bladder gradually. The size never changes suddenly. Fins, tail, and air bladder make the fish even more free in the water than birds are in the air. Airships as well as ships of the sea are built upon lines worked out from studies of the bird and the fish.

FISH COVERING

The covering of fishes is generally of naked skin or overlapping scales. Another thing which man did not need to invent outright, since numerous orders of fishes had tested it, is the laying of flat plates so that one-third of each is covered by the one above leaving no open seams. We say that the scales are like the tiles or shingles on a roof, but it might better be said that man has put a scaly covering on his house like that of the fish. The scales are smooth, so that the surface makes no resistance to the water, as without nail or rivet the fish holds them tightly down.

HOW DO FISH BREATHE?

In many lower forms of sea life, water, flowing over surfaces which can take oxygen from it, renews the blood of the creatures while it also brings food and carries away waste products. In fishes we come to true regular breathing apparatus. The gills of a fish are nearly, if not quite, as perfect in their powers as the lungs of land animals. A piece of the gill of a fish if put in water may be made to show the beautiful feathery parts over which water flows as freely as the outside water. Oxygen from the air in the water constantly enters the blood which flows through the gills. A fish out of water can take little if any oxygen from the air.

THE FISH HOSTS

Hundreds of millions of eggs are found by actual estimate in the roe of some species of fish. Even when allowance is made for the large numbers eaten by other creatures, and for the large numbers destined to supply fish markets of various countries, enough fish remain alive to keep the numbers about the same year after year. The fisheries of the world leave the population of the sea very little thinned out.

The herring family is an example. It was estimated many years ago that two thousand millions were consumed in Europe alone. Charles the Fifth, in 1556, erected a monument and ate a herring over the grave of a fisherman in the island of Zealand who had improved the art of preserving herring.

Sardines, a smaller species of herring, are taken, fifty thousand or more in a single hour, and four hundred thousand have been a single catch on the coast of Sardinia in the Mediterranean Sea.

Seaweeds, soft-bodied starfishes, sea anemones, and jellyfishes fill the waters where schools of fishes make their feeding grounds. It is true also that bigger fishes eat smaller ones even of their own species. It is the law of life to devour and be devoured, but the other truth should be set over against this one, that the creatures kill only for food. The quickness with which wounded parts heal, if wounds of battle are not mortal, helps us to waste little horror on what is called cruelty. If the lives are seldom free for long from danger, the fishes do not suffer either in fear beforehand or memory afterward. In general, Nature sets her children an abundant table.

Eels migrate, not from salt to fresh water, or from deep to shallow, but from the rivers of both Europe and America to one of the deepest regions of the Atlantic Ocean, near the West Indies. They do not return to the rivers after spawning, but in from one to three years the baby eels find their way to the streams from which their parents came.

The tunny fisheries of the Mediterranean have been important for centuries. They exist because of the migratory habits of this superb swimmer. Fishermen have long believed that the tunny comes from the open ocean into the Mediterranean to spawn, then travels to sea and more than half way around the earth before its next spawning season. It is quite probable that these wanderers do travel from ocean to

ocean, but it is now believed that numbers of them winter in the depths of both the Mediterranean Sea and the Atlantic Ocean. As the spawning season approaches, they migrate first toward the surface then toward the coast of both ocean and sea. There are important fisheries outside the Strait of Gibraltar as well as inside. After spawning, some of the larger fish follow the shoals of herring, which they evidently regard as choice food.

A FISH THAT TRAVELS NEARLY ROUND THE WORLD

We know of bird migrations in great flocks and covering great distances. Not so much is known of the way great schools of fishes of the same species have different feeding grounds at different seasons. Each year between March and July great numbers of sturgeon appear in the rivers of Europe and North America on their way to fresh water to spawn. These fish are seldom caught at sea, but during these months of the breeding season, sturgeon fishing becomes an important industry.

The salmon is another fish that migrates in the spawning season to the fresh water of the rivers. Sometimes salmon, which spawn only once, spend as long as a year in the rivers before laying their eggs. No matter how long the period, they eat no food after entering the fresh water.

In the large rivers of the Pacific Coast of North America, the salmon may travel one thousand miles to the spawning beds. No wonder they are so exhausted that they die soon after the eggs are laid.

Most fish do not migrate to rivers; but many kinds migrate from the deep ocean to the shallower waters in order to spawn. In summer, mackerel are found in immense schools near the coasts of Europe and America. During the autumn they travel to the North Sea and other regions where herring are abundant. In winter, they disappear once more into the deep waters of the Atlantic.

By courtesy of Fleming H. Revell Co.

STRANGE ANIMALS FROM DEEP WATERS

Left: Dwellers in the extreme depths of the ocean. Right: The shark seizing his prey.

TURTLES OR TORTOISES OF THE SEA

ONLY a single branch of the turtle tribe has taken to the sea, unless it be true of the rest that in earliest times they were sea creatures who afterward came to live on land.

Even the sea turtles are true air breathers, and the mother turtles must come to land to lay their eggs in order that their children may start life on shore. This return to land, however, costs the mother dear, for man has learned the value of her flesh for food and the beauty of her shell for ornament, and takes this time to secure them.

WHERE TURTLES BELONG ON THE LADDER OF LIFE

It would seem that turtles belong before fishes in a rising scale of life, as other creatures do whose soft bodies need the protection of a shell. But turtles have many marks of a higher form of life, too many to describe here. They are closer in class to lizards, alligators, and serpents, for they have an internal structure that is less like that of the fishes and more like that of the highest creatures. The very shapely skeleton may be traced on the inside of the shell if the soft parts of the creature are taken away.

HOW A TURTLE MAKES HIS LIVING SHELL

The turtle saves himself from enemies by making a strong box to live in. This box, while he is living in it, is bound to be alive and to have the parts of a skeleton of regular form. A sea turtle is like a frog, so cased in armor that it cannot jump. It is a real part of the living animal, not merely an enclosing case. How is it that the shell of the turtle is a skeleton? This is the way: The growing ribs of the young turtle while they are soft like gristle flatten out into bony plates and join themselves together so firmly that the shell would never break at one of these seams. These rib plates, which protect the turtle, are joined also to the flattened-out sections of the backbone. There are twelve pairs of these scales; you can trace and count them. What takes the place in the turtle of a breastbone in creatures like birds, is spread out to make the under side of the box-like armor. The joints of the neck remain free

A TURTLE SWIMMING

Even the hungry sea fishes make respectful way for her, as her shell makes her too formidable to attack.

enough for easy movement, as do those of the tail. The row of plates all around the edge, twenty-three in number, bind the ribs together but do not belong to the skeleton, and are merely skin bones like our own nails.

LIVING INSIDE HIS OWN BACKBONE

How the shoulder and hip bones come to be inside the ribs instead of outside, as in other animals, is a puzzle till a baby tortoise is studied which has them outside just as other vertebrate animals do; but as the baby grows up the bony plates press forward to cover the shoulders and backward to cover the hips, till the creature appears to be living inside his own backbone and ribs.

HOW OLD DOES A TURTLE LIVE TO BE?

The tortoises have managed to hold their own in the world, yet against many dangers. Living

slowly, they go on growing up to eighty years old; sleeping much of their time, they seem to ask but little of life. On land they shuffle awkwardly along, but in the sea they dive and rise or plow their way with great ease. Turtles swim mostly with their front limbs, the toes of which are joined and are flattened out to the shape of an oar.

Man is almost the only enemy the sea turtle has, and such a hold has it upon life that nothing short of utter tearing apart is fatal to it. An air breather, the turtle is also a water animal, for it can stay "below" a short or long time as it pleases, or come ashore for an equal period. Most of the creatures of the sea are the worst of gluttons, but it does not seem to matter to the turtle whether it eats or not, and it can go without light or even air to a degree that is marvelous. Except for short periods it is a sluggish creature, and makes up for living slowly by continuing to live much longer than do many other creatures.

TURTLE BREEDING

The mother turtle, feeling the weight of the eggs she carries, has an impulse to flee. On some fine morning her sluggish habit is exchanged for a rapid, rhythmical movement just below the surface of the water, and eighteen miles an hour is not too much speed for her to make. Such clumsiness to be followed by such speed is a marvel. Inside her shell she is in little danger from the hungry sea people, and like a miniature steam propeller her broad fans beat the sea like paddles. After a day of this unbroken voyage the great turtle comes to the place which she has been blindly aiming to reach. She drags herself up above high-water mark and rests. Her first act on coming to shore is furiously to fling her strong flippers, making the sand fly like a tempest till she is hidden in it from view.

Now for two days she will lay her eggs, one hundred to eight hundred, according to the kind of turtle. Big, round, white eggs! The numbers of young which are started in life are fewer in turtles than in fishes. The danger of their being destroyed is much less. The sun does the rest for the turtle eggs and the mother can go her way back to the sea.

If you were a creature weighing a thousand pounds, would you care to stay behind to see such tiny babies hatched, little black turtles, perfect, though the shell is soft, but only an inch across in size? The mother turtle does not think it worth while.

The baby turtle feels its need of shelter, and gropes about till it comes upon a patch of gulfweed whose branches hold numberless tiny living creatures. The other babies with the same instinct do the same, and the masses of gulfweed make a nursery for them all. When their shells become hard, which happens before long, the turtles take to the sea, and in a year's time are well out of danger, having a weight of twenty-five pounds, perhaps, and a thickness and hardness of shell which, unless the head and paddle legs are thrust out, makes the turtle practically safe.

The green turtle is four or five feet in length and weighs from four hundred to eight hundred pounds; but it has been known to double these dimensions and increase in weight in proportion. The flesh of smaller ones is of greater delicacy. Crocodiles live in the same waters as turtles, and both they and fishes are ready to spring upon the mother turtles when they are gaining the water after a visit to the shore. The flesh of the tortoise-shell turtle has not a good flavor, and the creature is sought for its fine clouded-colored shell. This outer shell is said to change every year. Great cruelty is practiced by heating a shell so that the creature will tear itself away from it. The shell, softened by boiling water, is shaped into whatever form is desired. A single turtle yields ten or twelve pounds of this valuable tortoise shell.

THE STRENGTH OF THE TURTLE

It is better not to try to find out how strong the turtle is. Fingers have been lost by trying to see if a turtle was surely dead. Getting a hold upon a big turtle and trying to turn it over sometimes ends in being dragged down through the blinding sand it stirs up until one must let go or be drowned. Breeding time is harvest time for turtle capturers, who have only to succeed in turning the victim over to hold it safely. From the time it is caught the turtle will not touch food, however long it is kept in captivity before reaching the market.

Underwood

JAW OF A WHALE, SHOWING BALEEN OR "WHALEBONE"

HALF-IN-HALF CREATURES

IN the old myths we find stories of many beings half human and half animal — centaurs with the body of a horse and the head of a man, and mermaids with tails like fishes instead of lower limbs. As very often happens, the true story in this case is fully as wonderful as that which men imagined. The inhabitants of the sea which we call "half-in-half creatures" are half water and half land, or half water and half air. They are the few which are left of the many prehistoric animals of which you have read in the earth-story, that lived on our earth when it was covered with water. Most of them died out when the waters fell and dry land took its place; but a few, some little and some big, were able to adapt themselves to the new conditions.

THE WHALE AS A MAMMAL

Most people think of the whale carelessly as a kind of fish. It is only in what fits it for its life in the water, instead of in the air, that the whale is like a fish. Just what is it? One of the points of likeness between the whale and the fishes is the lack of a neck. The slim gracefulness of a spindle-shaped body does not allow outsloping shoulders. Creatures that move best in the water have their limbs folded closely to the sides and made to take as little room as possible. Fins are little more than long fingers which have found no use for themselves except to move up and down, or from side to side. The lack of a neck with freedom of motion for the head is seen to be more or less marked in all the vertebrates which live in the sea. A very flexible backbone has to make up for the loss of free motion for the head.

The whale is unlike the fish in that it breathes with lungs rather than with gills. Its nostril, or "blow hole," as it is often called, is placed well toward the top of the head. When the whale is under water, the nostril is closed, so that water cannot enter it.

The whale belongs to the group of animals called Mammals. Mammals feed the young with

A GROUP OF AIR BREATHERS

A. Sperm Whale. B. Pigmy Sperm Whale. C. Finback or Razorback Whale. 1, 2, 4, 5, 6, 7. Porpoises and Dolphins. 3. Cowfish or Grampus. 8. Killer Whale, or Sword Grampus.

milk. Mammals are warm-blooded animals. The temperature of warm-blooded animals remains the same at all times. Whether the water is warm or cold, the temperature of the whale's body will remain the same.

THE SIZE OF THE WHALE

The whale is the largest animal that has ever lived. The great blue whale attains a length of one hundred and ten feet and its weight may be as great as one hundred and fifty tons. The head is extremely large, sometimes as much as one-third the length of the body. The eyes may be four times as large as those of an ox.

The eyeballs cannot move. Often a whale rises to the surface and, holding itself in a vertical position, turns its entire body around to look over the sea in all directions.

HOW THE WHALE SWIMS

The tail of a fish proper is placed vertically. It moves from side to side. The tail of a whale is set horizontally. It moves up and down with tremendous force. While only five or six feet in length, it is eighteen or twenty in width. Because the greatest strength is in this upward and downward stroke, rather than in the sidewise ones, the whale is very swift in spite of its great size. From their rapid motion whales are called "birds of the sea."

Some kinds of fishes never rise to within a few feet of the surface of the sea, and never go below a certain known depth. They are not fitted for different weights or pressures of water. The weight of water in the deep places of the ocean is almost inconceivable. A whale of usual size would have to bear a pressure of two hundred thousand tons, or one hundred and fifty times as much as in air. The elastic coat of blubber could not resist such pressure if it were not a part of the skin itself, with its open fibers making a sort of India-rubber cushion. The oil of the blubber being so much lighter than water helps the whale in rising, and the pressure can be made to work under control in descending. It is a marvel of adaptation.

The whale is found in all waters, cold or warm, deep or shallow. It rests and feeds upon the sea bottom, but rises as often as every ten or fifteen minutes to breathe the air which is its life. The sperm whale takes sixty or seventy breaths in ten minutes or so. Then it goes below for an hour and a quarter, as a rule. Repeating these "breathing exercises" is a part of the regular life of the whale.

MAN THE WHALE'S CHIEF FOE

In times of fury or rage the cachalot or sperm whale is one of the most dangerous and dreaded monsters of the deep. As a rule, whales are peaceably inclined. The greatest danger can come from a blow of the powerful tail. It is said that a large whale can splinter a small boat

Underwood

STRIPPING BLUBBER FROM THE WHALE

into bits. Yet whales are playful creatures. The young ones will play about a ship for hours.

Whale fisheries are attended with great dangers, but there is never a lack of people who will face the danger and brave the hardship for the hope of reward. A quarter of a century ago the business of whaling threatened to die out, but now it has been revived.

SEA PETS

The smooth dolphin and the porpoise are interesting as miniature whales. They are most familiar as seen from coast or ocean steamers. The porpoise may be sighted almost any day in summer. Passengers never tire of watching their graceful forms, the ease of their motions, and the playful gamboling with which they surround a ship as if to amuse and entertain those on board.

Dolphins belong more to distant waters, but with the more than sixty species, there are some for nearly all waters. They even go up wide-mouthed rivers. It is not difficult to tell the two apart, for dolphins have a quite extended snout, almost like a beak, and the mouth is rich with teeth, the dolphin having more than any other mammal, ninety in each jaw. It is not when the dolphin shows its teeth that one remembers the engaging qualities for which it is famed, but it does not open its mouth when sporting for us to see.

THE DOLPHIN IN HISTORY

The dolphin of story has a most distinguished pedigree. It was a great favorite with the ancients. Among the Greeks it was held to be sacred to Apollo, who was worshiped at Delphi with dolphin symbols. It is figured on many early coins. In the twelfth century the figure of a dolphin was on the shield of a family of princes. There is a legend that Dauphiny, a province named for it, was given to the king of France on condition that his eldest son should be called the Dauphin. This title was retained by the prince till 1830, when its use was discontinued.

The smooth, glossy skin in some varieties is brilliant, "beyond the power of words to describe," it is said. All the species are said to show wonderful changes in color when dying.

It is now understood, however, that many of the most remarkable ancient stories of the social habits of the dolphin belong to another fish of the same name. While playful, it is to be feared that the dolphin is rather wolfish in its ways. It destroys fish whose value is much greater than its own, and the way mackerel, cod, and herring behave in the water when a school of these animals is near by shows that they do not share our attraction to the dolphin or to the porpoise. But such considerations are forgotten when we see them darting about, in and out of the water by turn and hardly creating a ripple.

THE KILLER WHALE OR GRAMPUS

Among the dolphins the killer whale or grampus is the most bloodthirsty. It is the only one which feeds upon warm-blooded animals. It seizes seals with its strong, sharp teeth and will devour its own relations, the porpoises. Even the larger whales are attacked by it and dreadful battle ensues. The mothers of the seal and walrus families try in vain to save their young. The grampus will swim under and shake them from the mother's back. How much a grampus can eat is told by those who kill and dissect them. Fourteen seals and thirteen porpoises are named in one of the stories.

FIN-FOOTED CREATURES

The seals and their fin-footed relatives make a group by themselves. They are the natural kind of creatures for such places as the Aleutian Isles, the entrance to Behring Straits, Nova Zembla, and Greenland. They have what they plainly need, flippers for the sea and true feet for the land. The front paws are more like feet, and the hind ones like flippers, or even fins. The skeletons show all the kinds of bones which a land animal has in its limbs. The packing of so much fat around the parts, and using these parts so little for walking or holding, has given us a half-in-half animal which, when we see it for the first time, seems a freak. As we get acquainted with the funny creatures, with the almost human look in their eyes, we come to admire them.

11 FEET 4 INCHES
TO LEVEL OF HIGHEST PART OF BACK OF ELEPHANT
SCALE IN FEET
6 FEET FROM GROUND TO TOP OF SEAL'S HEAD
SCALE IN FEET
A. HUGH FISHER

THE TRUNKED ELEPHANT-SEAL OF THE SEA COMPARED WITH THE ELEPHANT OF THE AFRICAN JUNGLE

THE SEAL

The seal is one of the several great air-breathers that make their home in the icy seas of the polar regions. There he is looked upon as the greatest blessing of the Eskimos for whom his flesh serves as meat and his oil for light. The seal was probably first a land-liver, but later adapted himself to sea life, by exchanging flippers for front legs and uniting his hind legs with his tail to form a swimming fin. So his land movements are impossibly awkward and his gait sadly slow, though he can waddle on his fin-like feet. Being an air-breather and living in the water necessitates his coming to the surface to breathe; when under the ice, he has to make a hole in the ice to breathe through. This habit often costs him his life.

Several observers have noticed that the common seal is very fond of music, and one writer tells how the sound of his flute would bring a number of seals out of the water within twenty or thirty feet of him.

THE SEAL FROM WHICH WE GET OUR FUR

The otaries, or fur seals, are distinguished from other seals by an external (outer) ear. They are found in great herds off the coast of Alaska in the Pribilof Islands. When the seal hunters first came to the islands the animals were so tame that they would even look on while their companions were being killed. But now they have learned a little wisdom, and take care to climb to the top of a rock or steep place, where they can throw themselves into the sea.

In recent years, seals have been taken under the protection of the United States and other governments. Only so many seals are allowed to be killed each year. Thus the seal is saved from total extermination or destruction. The seal of our caps and coats looks very different from the covering of the live seal. The long gray hair of his coat has all to be pulled out before you may discover his value in the fine yellow-brown fur that is hidden below. This undercoat must be "London-dyed" to give it its full money value — hundreds of dollars for a single garment of Alaska seal.

THE SEA OTTER

Those who are familiar with the form of the common otter can trace the preparation for sea life in the sea otter, which has almost wholly forsaken the land. Weird-looking creatures they are, as they are seen in hundreds off the coast of California and Alaska. Till something startles the mother otters they bask in the sun on the wet rocks. At the slightest fear each mother will pick up her little one with her teeth and dive under water. Except when caring for their young the sea otters hardly need the support of land. Turning on their backs they can divide and eat their prey, holding crabs, sea urchins, or fish in their front paws. It is most interesting to watch them. They play

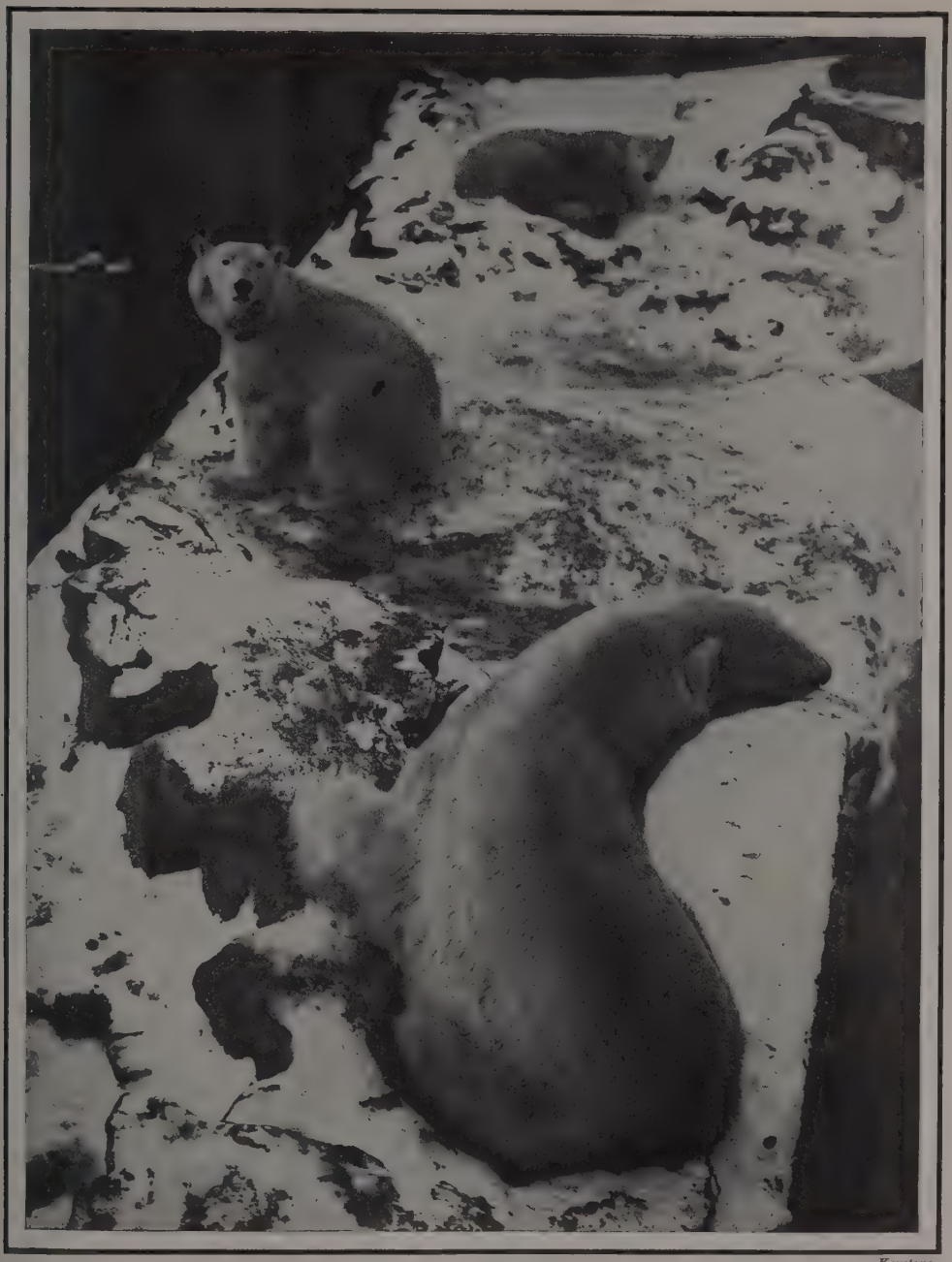
THE SEA OTTER

with and nurse their babies in the same pretty fashion.

But while this kind of otter has all the freedom of the sea life, it is distinctly four-footed, almost even four-legged, for its form is much like that of a weasel. Land and sea, like two good fairy godmothers, seem to have brought each her own best gifts to the christening of the otter, a land creature whose destiny it was to be to follow the sea.

THE POLAR BEAR

Since so many people have been attracted to the Arctic seas, and explorers have described their winter quarters when icebound, we do not think the life of the polar bear so marvelous as we formerly did. Indeed it is in the bear's white coat that the Arctic explorers are kept safe;



Keystone

POLAR BEARS

and it is when these men return to lower latitudes that they "take cold." The polar bear is a most interesting animal in the way it is suited to the icy waters where it makes its home. No land bear can twist and turn as it does. The polar bear's body is longer and its spine is more flexible. One has been seen forty miles from any coast and with no ice in sight to give it a rest. For movement on land the soles of the polar bear's feet are covered with close-set hairs, a special help for climbing the slippery ice cliffs. It is only the female bear which hibernates; that is, goes into a cave, which perhaps it may make for itself, to sleep away a part of the year and make ready to bear and rear its young. The male bear spends the winter in hunting. After the two cubs are born, the male and female often hunt together. The cubs follow their mother on these expeditions.

As a seal hunter, the polar bear is unexcelled, but much of its diet is obtained from floating carcasses of whales and fishes. The average length, when fully grown, is six to seven feet. It is entirely white, except the tip of the nose and the claws, which are jet black.

A VEGETABLE FEEDER

The impression all these creatures make is of devouring and being devoured. It is the law of life with them. There is no unnecessary torture, and it is good to remember that beyond the needed instinct to avoid danger there is no fear of death. The sea cow, on the other hand, is a gentle, peaceable creature, which feeds upon vegetable food, grasping the seaweeds with its upper lip and nipping them off with horny plates hanging from the roof of its mouth. A family of sea cows, father, mother, and child, has been seen wandering up the great rivers of South America or Africa, feeding under water, and only lifting heads out of water with a snort to take in fresh air. They must have been much more numerous in the forests of seaweed of older times, one to two hundred years ago; but sailors found them good eating and their ranks were thinned. It is probably the sea cows which have given rise to the stories of mermaids. No traces of hind limbs are shown in the thin, wide, shovel-shaped tail, not set edgewise, but so as to lie on the water like a leaf. The front limbs are as good hands and arms as are those of the seal. The sea cow, or *manatee*, as she holds her baby to her breast looks like an uncouth mother with her child. In the dugong the front teeth grow to form good-sized tusks.

BIRDS OF THE SEA

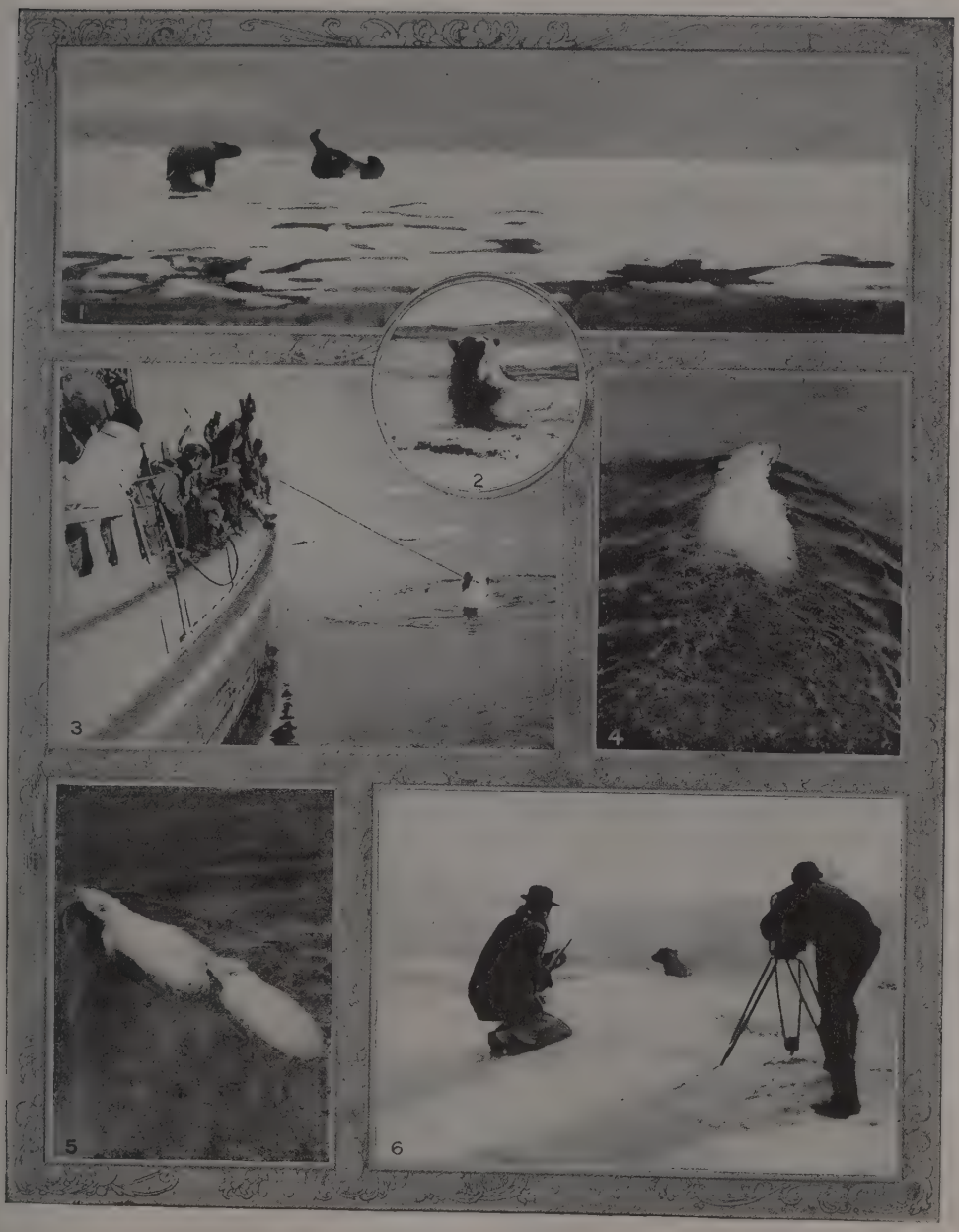
IF it is shown that any of the bird tribes belong to the sea more than to the land, then not one of the larger classes of vertebrates will be without its representative in the ocean world. The reptiles, it is true, have only the sea tortoise or turtle and some near relatives. We could hardly have expected that every great class of the animal kingdom would have a showing in the sea, but so it is, and it is also true that, on the whole, the sea is a better place than the land for studying the steps from lowest to highest in their natural order in the classified animal world.

THE SEA GULL

Passengers on the ocean steamers going between America and Europe always watch the gulls that fly around the ship. There will be a great flock of them at the start, but they thin out, till perhaps only four or five remain. They act as if they were really meaning to go across to Europe. By the third day the last one is missing, and the straggling ship's escort is making its way back to the shores it left. We should like to think that the birds follow the ship for social reasons, but it is probable that the tempting food thrown into the sea by the ship's cooks is the secret of their devotion.

THE STORY OF A PET GULL

Yet gulls are easily tamed. A story is told of a gull caught near Montrose by a Mr. Scott. He cut its wings and put it in his garden, where it lived happily. It came to the door to be fed, and answered to its name, "Willie." The wings grew long again, and the bird finally joined a flock of gulls and flew away. It came back from time to time to pay visits, and kept up its tame habits. At the end of the season Willie went away with the flock, but to the great joy of the household he returned the next year. In this



PHOTOGRAPHING A POLAR BEAR

1. Approaching him. 2. The king of the North. 3. Captured. 4. A rush away. 5. Escaping. 6. The farewell look.

way he came and went for forty years. He visited the family, ate out of the hand of any of them, and answered to his name. One year he failed to come. The family mourned over the loss of their pet. A year later a servant came to the breakfast table one morning to say that Willie had come back. In a year or two after this the bird failed to appear. Gulls are seashore birds rather than sea birds. They sometimes go far inland in rivers and lakes.

Terns, or sea swallows, are smaller than gulls. They are most elegant in their forms and graceful in their movements. They migrate to southern waters in cold weather.

THE GUILLEMOT

Guillemots are seen much farther out to sea than gulls. They are known by their black and white plumage, their short necks, and their long, sharp beaks. A guillemot is from six to ten inches in length. Vast numbers of these birds gather on some rocky island at breeding time. Dr. Kane, the first of our Arctic explorers, wrote that it was not uncommon to take a hundred guillemots in a couple of hours. And Sir John Franklin salted and stored a two years' supply for his ill-fated vessel. The guillemot lays but a single egg on a bare ledge of rock. The egg's peculiar shape makes it roll round and round instead of falling off. Guillemots dive and fly under water to get their meal of small fishes.

THE STORMY PETREL

The stormy petrel is a bird of the wide ocean. It rarely comes to land except at breeding time. Always on the wing is the story of the petrels which will follow a ship for days, resting only on the sea itself. The same petrel has been seen in two places half across the world. Sailors tie bits of cloth to a petrel's leg, marking the place and time of seeing it.

No one need doubt that stormy petrels enjoy a storm. Long before sailors detect signs of a storm, these gloomy birds will gather in large numbers and make their piercing cry as if to warn the crew of coming danger. They may be seen in great flocks skimming the water, or diving into it to catch fish which do not come to the surface.

One of the petrels is called the Cape Pigeon, and but for its webbed feet the petrel is not unlike a pigeon. Some varieties are sixteen to eighteen inches in length. The giant petrel is nearly twice this size. As companions of the lonely whalers these birds have come to be much beloved. The rocky St. Kilda, one of the western islands of Scotland, is a famous breeding resort for petrels. Great rocks are covered with them. Mother Carey's chickens, a small kind of petrel only about six inches in length, look like chimney swallows in the length and spread of their wings. The plumage of most petrels is black and white, with purple reflections.

The name "petrel" is a form of the word Peter. It was given to these birds from the ease with which they walk or run long distances on the water. Some of the petrel habits are rather unpleasant. It has a bad name as a robber of other birds' nests, and some species dart at gulls or other birds which have food in their bills and make them drop it so as to catch it themselves.

THE ALBATROSS

The biggest of the petrels is the albatross, which measures as much as eleven feet between its outspread wings, and is fully four feet from beak to tip of tail. A curious fact is related of the albatross. When it wishes to rise from where it is resting on the sea it has to run a long way, like a running ostrich, before it can mount in the air. Sailors give the bird a toss or lift it quite clear of the ship's rail if it has lighted on board. Once on the wing, the albatross is the most wonderful glider among birds. He remains in the air for hours, moving back and forth above the waves with scarcely a motion of his wings. He is found always in regions of high winds because such long continued flight as his is possible only when he is breasting a gale. While he seems to hang motionless in space, he is really balancing on a column of upward-moving air.

BIRDS IN PINAFORES

Auks and penguins belong among swimming birds. Their odd little wings help as paddles. The covering is of short, thick feathers which

BIRDS OF THE SEA

1. Blackhead gull and common gull. 2. Puffin and guillemot. 3. Giant penguins. 4. Albatross. 5. Pelican. 6. Manx shearwater and tern. 7. Puffins.

are almost like scales. Stories are told by sailors of the giant auk, but the race is now extinct. These auks used their wings so little that they came to be unsafe on shore. The whole tribe has been killed off.

Penguins are found in the south temperate zone. They cannot fly, but the wings help them in diving and swimming. Unlike most water birds, the penguin does not paddle with its feet. The legs are held behind as a rudder and the fin-like wings serve as paddles to send the bird through the water. Their movements in the water are quick and graceful. On land they are awkward. Great camps and rookeries of them show how social they are, but their bird government cannot be of the best when the stronger steal the eggs of the weaker. The king penguin is said to be the greatest thief of all. One called the jackass penguin sets up horrible brayings at nightfall. Penguins are nearly erect as they sit on the edge of a high cliff. They have been compared in their attempt to walk with a dog which has been taught to dance a minuet. And yet the birds are well furnished for the life they lead, except that man has discovered their great rookeries only to destroy them.

THE PELICAN

The brown pelican will be the last of these interesting, though odd-shaped, birds. Sea birds are all gluttonous feeders and their flesh is full of oil. Most of them resort to robbery, piracy, and utmost cunning in getting their food.

Pelicans are large, heavy birds. They are very awkward in their motion on land. As swimmers they can distance their pursuers. Their odd appearance is due to their tremendous bills with a pouch on the lower side, in which they can store fish which they catch, so as to eat it at their leisure. One of the pelican's ways is to disgorge its food after it seems to have swallowed it. It does this to feed its baby birds. These birds serve a useful purpose in taking care of the offal from dead whales and other sea creatures. Pelicans are found on the Florida coast in winter, but go to inland lakes to breed.

THE LAST WORD

THE study of life in the sea shows us many things we had not always realized. First, that the sea is almost a world in itself full of living creatures, and of vegetation of wonderful variety. Both plants and animals multiply with marvelous rapidity. Only as it is the law of their life to prey upon each other is the number kept in proper bounds.

The second point of interest is that practically all of the forms of sea life have relatives in fresh water or on land. Crabs, shrimps, and lobsters are related to insects. Clams, oysters, and sea snails are the same kind of animal as the common land snails.

In past ages, some animals along the ocean shores became imbedded in the sand and could not escape. As the sand hardened into rock, these bodies made imprints which we call fossils. Of course, most animals died without leaving fossil records, so that this history in the rock is incomplete.

The fossil records which have been found show that some forms of life appeared much later than others. Some animals found in the ocean today are similar to fossils found in the oldest rocks. Others are quite different from these earliest animals, but resemble the fossils of later periods. On the other hand some of the animals which have left fossil records have entirely disappeared from the earth.

[*For more stories on these lines, turn to Volume Ten, which continues the story of "The Wonder of Life," and to Volume Three, where Dallas Lore Sharp shows you how to go out and find out nature lore for yourself.*]

Courtesy of National Academy of Sciences

THE MARCH OF SCIENCE

By Mary Ellen Whelpley

(We have been guided in our selection of scientists by those chosen for the panels on the National Academy of Sciences in Washington, D. C. These beautiful bas-reliefs are reproduced here and in Volume Two.)

THE FIRST SCIENTIST

THALES (640?–546? B. C.)

THALES of Miletus, who lived in the seventh century before Christ, was the foremost of the "Seven Wise Men" of Greece. He seems to have been an astronomer, a mathematician, and a statesman. Because he thought independently, he has won a place as the first scientist of the ages.

Up to his time men had accepted the world as it appeared to be. No one had bothered to seek for a reason in things. But Thales looked at the beautiful city of Miletus situated on the southern shore of the Latmian Bay and puzzled about the shining white buildings and the blue waters. He wondered just what the world really was: What was beyond the bay? What lay beneath the green hills and valleys which he walked over? Above all, what was the relationship of the earth, the sky, and the sea? Not only did he puzzle, but also he observed. So to-day discoveries are made by people who puzzle and see in the world about them more than is evident to the average person.

At length Thales came to the belief that water was the one original substance out of which the world was formed. Of course, later thinkers proved that his idea was wrong. However, in seeking for a natural cause and in thinking that the entire world was a unit — that is, made of one substance — he went farther than any thinker before him. The important point is that observation and reason led Thales to the belief which he held.

He had seen that water was everywhere. He had watched the blue waves wash on the shore of his home and had observed the mists and fogs which came in from the sea. He had noted that rain which came down from the sky brought greater fertility. No doubt he believed, as some people did at that time, that rain turned into earth. Then this liquid appeared again in all things. He could crush it out of his fruits and berries, it came as sap in his olive trees, and as blood it even ran in his own veins. Therefore, he decided that

there could be no life without some form of water.

On the other hand the water did not remain in the earth. It seemed to come out of the soil as dew, and certainly there were the springs of fresh water which bubbled out of the ground. On a sunny day he had seen this moisture drawn away into the sky. So Thales reasoned that there was a world process going on about him — from water to water. It must be that all things were formed from water and that the earth itself must finally turn to water again, in which case the earth probably floated upon water.

This was not truth, certainly, but it was a thoughtful explanation of the universe. Thales had given the world a new idea which was to lead to other ideas. For that reason he is known as the first scientist.

Now, as to his other achievements: He predicted an eclipse of the sun which actually occurred, just when he said it would, on the twenty-eighth of May, 585 B. C. The story of this total eclipse, which ended a war, is told earlier in this volume.

He could also turn his knowledge to strikingly practical account. Miletus, in his time, was much occupied with commercial enterprise, and Thales' attention was directed to problems of the sailors. He showed that it was better to steer a ship's course by the lesser bear which ended in the pole star, than by the greater.

It is said that he introduced the Egyptian knowledge of geometry into Greece. The Egyptians had discovered the first elements of geometry in measuring the lands made fertile by the floods of the Nile. Thales solved the problem of measuring the height of an inaccessible object by comparing its shadow with that of a small object which is accessible.

His interest in problems of the day led him to take an interest in politics. The Ionian cities of Asia Minor were continually quarreling among themselves. His advice was that they should unite in one federal state in order to mass their strength and thus maintain their liberty. They were not wise enough to follow his advice, however, and they fell one after another before the Persian army.

The following legend shows how he was regarded by the men of his time. The fishermen near Miletus where he lived drew up a golden tripod which it was said had been thrown into the sea by Helen of Troy. It immediately became an object of controversy between the cities. Arms were taken up to secure its possession. The contest was ended when Apollo decreed that it should be presented to the wisest man they could find. It was sent first to Thales. But Thales refused it and sent it to Bias of Priene who he said was wiser than himself. He also refused it, sending it on to another. Solon, the lawmaker of Athens, had it offered to him and he rejected it. At length, after being offered to many men, it came to Thales for the second time, and he refused it also for the second time. The tripod finally came to rest at the shrine of Apollo at Thebes.

It is no wonder that Thales won the distinction of being the wisest of the "Seven Wise Men." Someone has said that thought came into the world with this man of Miletus. And so it may be, for all men and women who wish to know something that has not been written in books and that no one can tell them have followed in his footsteps. They have found it necessary to think independently and to base their conclusions on reason.

THE FATHER OF PHYSICS

DEMOCRITUS (460?–362? B. C.)

"I AM the most traveled of all my contemporaries; I have extended my field of inquiry wider than anyone else; I have seen more countries and climes, and have heard more speeches of learned men. No one has surpassed me in the composition of lines accompanied by demonstration not even the Egyptian knotters of ropes or geometers."

In this way Democritus described his accomplishments. Although this may sound as though he were blowing his own trumpet, he was only speaking simply and truthfully in the fashion of the ancient Greeks. The facts of his life show that he was quite modest.

Democritus was born in the commercial colony of Abdera, which was situated on the borders of Thrace and Macedonia close to rich gold mines. Since he inherited wealth and property, it was possible for him to travel in

the East in search of information. He remained in Egypt for seven years where he studied mathematical and physical systems of the ancient schools.

After he returned home, he worked out a new explanation of the nature of the world. Thales gave the first natural explanation, and Democritus wins a place beside him for the originality of his doctrine. Democritus' explanation was that the universe contains only atoms and the void. These atoms, physical particles of only one quality, move and combine mechanically in the void or empty space. Thus the world was constructed. He further declared that there were an endless number of world systems through space.

The importance of his atomic theory is that it is actually a forerunner of the modern theory. Of course, Democritus lacked the modern telescope and spectroscope to prove his theory. It is the more remarkable, then, that he should think out a scientific explanation of the nature of the world which was to influence innumerable scientists after him. For this reason, he is considered the "father of physics." Two thousand years later, another and perhaps greater thinker, Galileo, was to work on much the same fundamental principal.

There must have been something particularly winning about this great natural scientist, for he seems to have been very popular with the people of Abdera. He was called the "smiling philosopher." Perhaps his travels had given him a larger tolerance and greater understanding of the follies of men. At any rate his intimates are said to have enjoyed his geniality of disposition and his optimistic temperament. He taught them that life was beautiful and that men should enjoy its gifts, but always temperately and with consideration for others. Democritus, himself, was a man of high moral character and strong religious tendencies.

The way in which his countrymen regarded him is shown in the following story. It is said that he returned to Abdera penniless after his travels. In this plight his countrymen granted him five hundred talents. However, they thought he acted strangely and feared that his mind was unbalanced. This led them to call Hippocrates, the first great doctor, to examine his mental condition. Hippocrates came. He satisfied the people that they had nothing to fear for Democritus and then stayed to enjoy philosophical discussions with this learned man. So much did the two sages enjoy their talks together that they continued to exchange ideas by letter. The letters remain. Of the actual contact between the two we cannot be sure. It is known, however, that Hippocrates did visit Abdera — the town was famous for learning in the lifetime of Democritus — and so it is not unlikely that the two talked together.

THE FATHER OF GEOMETRY

EUCLID (320?–275? B. C.)

"THERE is no royal road to geometry." This is the answer which Euclid made when King Ptolemy I of Alexandria asked if there were no "shorter way in geometry than the elements."

Many high-school students to-day would echo the king's question and perhaps sigh over the great mathematician's answer. For even at the present time, more than twenty-two centuries since Euclid lived, his famous propositions in plane and solid geometry are taught in the schools almost exactly as he gave them. That is a great tribute to his genius. No matter what unpleasant associations you may have with the study of geometry, you cannot help marveling at the genius of a man whose teaching has never been surpassed.

Of Euclid's life we know very little. He was a Greek by birth and probably was educated at Athens. His great work began when he went to Alexandria to lecture in the University which was founded in the year 300 B. C. Euclid is supposed to have taught there the rest of his life. According to tradition he was noticeable for his gentleness and modesty. So great was the king's respect for this Greek teacher that he provided a special auditorium for his use and conferred on him every privilege and honor. Scholars of all nationalities came to attend his classes. Since Euclid gave his lectures in Greek, language schools were established where Egyptians, Hindus, Persians, Arabs, and all the other non-Greek students might learn his language.

Of his teaching, the following story has been left to us. A lad who had begun the study of geometry with Euclid inquired, after he had learned the first proposition, "What do I get by learning these things?" Euclid called his slave and said, "Give him threepence since he must make gain out of what he learns."

These are the only personal details of his life that have been recorded. For the most part his name has come to be almost synonymous with "The Elements of Geometry." The form in which the propositions are presented — the enunciation, statement, construction, proof, and conclusion — is directly due to Euclid. The entire book will always remain as one of the greatest examples of the logic of thinking.

Of course, there were mathematicians before Euclid. In fact his work contains a summary of all that had been discovered up to his time. But he begins at the very beginning and builds up his whole doctrine with such accuracy that scarcely any errors have since been found. In the development of sciences, mathematics is the first step. Until there was a Euclid to give a basis for strict scientific thinking, man could only take notes and speculate on the phenomena of nature.

THE FIRST GREAT ASTRONOMER

HIPPARCHUS (170?–126? B. C.)

HIPPARCHUS was the greatest of the early astronomers. He was a Greek born at Nicæa, which is in that part of Asia Minor lying near the Sea of Marmora and the Black Sea. His astronomical observations, however, were made in the island of Rhodes. Here he made a catalogue of more than one thousand stars. This was a great achievement, since no one had attempted making an accurate list before. He is also supposed to have invented the astrolabe, an instrument which was used to take the altitude of heavenly bodies.

He calculated eclipses and was the discoverer of the phenomenon known as the precession of the equinoxes. It was remarkable that he could have made this discovery when his observational instruments, compared with those in use to-day, were very inadequate. The exact cause of this phenomenon he was unable to explain, but no explanation was given until the seventeenth century when Newton discovered the laws which control the movements of the planets in space. (The equinoxes are explained on pages 11 and 12 of this volume.)

Hipparchus was an original thinker in mathematics, also. By many he is regarded as the founder of the science of trigonometry. Probably his scientific investigations were important because he combined careful calculation with speculation. (You may read more about his work as an astronomer on pages 4 and 60 of this volume.)

LEONARDO DA VINCI

(1452–1519)

IN Florence during the fifteenth century people were likely to think that there was nothing which Leonardo da Vinci could not accomplish. Usually we think of him as an artist, painting beautiful pictures and creating splendid statues. He was also an architect, designing magnificent buildings, and an inventor. He experimented with flying machines and was keenly disappointed by his failure. He probably designed the first canal locks, which solved the problem of how to sail across country and uphill. (You will want to read about him in Volume IV, pages 276 and 314, Volume V, page 284, and Volume VII, page 76.)

GALILEO

(1564–1642)

GALILEO was a great Italian astronomer. With the telescope which he invented, he was able to make a great many observations of the heavens and to show beyond doubt that Copernicus was right: the sun was the center of the universe and the earth and planets moved about it. He also gave the world the law of bodies falling to the earth. This law led to the discovery of other scientific truths. (You will find his story on pages 37 and 62 of this volume. Look also at the picture facing page 1.)

Courtesy of National Academy of Sciences

THE FATHER OF MEDICINE

HIPPOCRATES (460–359 OR 377? B. C.)

BEFORE the middle of the fifth century B. C., almost all the Greeks believed that illness was a punishment sent because the gods were angry. When they were ill, they would first try to please the god of medicine, Æsculapius, by sending a present to his shrine. Then they would bring gold to the priests in his temple to pay for treatment. Often this treatment was only a mysterious incantation said by the priest as he hung a bag containing a charm of calf's liver about the neck of the sufferer. If the person got well, the priests had worked a cure; if he was no better, the gods were still angry.

Hippocrates was the first person to abandon for good and all these mysterious charms and incantations. His ancestors had been priests of Æsculapius, but he separated himself from the priesthood. He believed that every disease "has its nature and nothing happens without a natural cause." Therefore, he examined each sick person to find out what his particular trouble might be. This was the beginning of the scientific study of disease. It is no wonder, then, that Hippocrates is called the "Father of Medicine," and often characterized by the added title of "the Great."

He was born in the little island of Cos, one of the Ægean Isles. Of his education little is known. It is believed that he traveled widely; it is certain that he observed closely everything connected with the profession of medicine. Although he taught and practiced in Thrace, Thessaly, Delos, and Athens, most of his work was done in Cos. Here, he became the head of a famous guild of physicians. Under his direction, all his associates and followers turned their attention to the careful observation and study of the patient.

Many of his writings which describe the proper way to treat diseases have come down to us. There are careful records of different fevers, and notes explaining that the same food for a person who is well will not do for a person in fever. Attention is also called to the necessity of watching for the critical point when the fever is at its height. Certain terms used by this great doctor, such as chronic, acute, and crisis, are in use to-day.

From his writings we find that he believed in the important process of self-repair. Under the right conditions, he thought that the body could do much for itself. Therefore, instead of drugs, he often prescribed a change of climate, or conditions which would make possible long quiet hours of sleep. Frequent bathing of the entire body, sometimes in cold and at other times in warm or hot water, was another

favorite remedy. His interest in the best living conditions led him to describe the proper aspect for a town and to discuss the quality of the water supply. One of his most famous works bears the title, "On Airs, Waters, and Places."

Various experiments were also made at Cos. One of the most important was the anatomical research of Hippocrates. He compared the structure of the human skeleton with that of other vertebrate animals. Thus, he is considered a pioneer in comparative anatomy. Not only did he write of the things which he had discovered to be true, but also he wrote of his failures. He believed that it was valuable for the younger men to learn of unsuccessful experiments and to know the cause of their non-success. One of his wisest sayings is: "Life is brief, but art is long, the emergency swift, the test deceptive, and judgment difficult."

In all that he did he sought to uphold the high moral ideal of the medical profession. This is shown further in the oath, known as the Oath of Hippocrates, which was administered to every practitioner in the school of Cos. That a part of it is still given to graduates about to begin the practice of medicine testifies to the high character and wisdom of this great doctor. In this he says, among other things: "In a chaste and spotless fashion shall I maintain my life and art," and "Into all the houses which I shall enter I shall enter for the benefit of the sufferers."

From the time of Hippocrates the Great, medicine has been a scientific profession instead of a business for magicians.

THE FATHER OF BIOLOGY

ARISTOTLE (384–322 B. C.)

ARISTOTLE has been known through the ages as "The Philosopher," or the master of those who know. Almost every department of knowledge has been influenced by his teaching. He left important works on such different subjects as astronomy, poetry, physics, philosophy, biology, and politics. His writings on biology, or the science of living things, show that he was a pioneer in this field and also a great original thinker.

Aristotle was born at Stagira, a Greek colony in Thrace. His father, who was a physician to King Philip of Macedonia, is supposed to have supervised his early studies carefully and to have encouraged his interest in natural science. When he was eighteen, he entered the famous Academy of Plato at Athens. Here he seems to have been a very brilliant student, for Plato once called him the "mind of the school." For twenty years he lived and studied in the intellectual atmosphere of Athens and the Academy. On the death of Plato he traveled in Thrace and spent some time on the island of Lesbos studying the seaside animals. From there he went to Macedonia to take a position as tutor of the boy who became Alexander the Great. When Alexander started on his conquest of Persia, Aristotle returned to Athens and set up a school of his own, which was known as the Lyceum.

All this training helped him to become a great naturalist. Since his father was a doctor, he had an early opportunity to study anatomy. The teaching of Plato had sharpened his power to reason things out and had also added to his stock of general knowledge. When he was established in Athens, he persuaded Alexander to have specimens of rare creatures from the strange lands which he conquered sent to him to be examined and studied.

He cut up the brain and hearts of dead animals in order to see how they were made. Then he examined eggs before they were hatched and found that the heart was the first part of the body to develop. Sometimes he spent months observing the habits of living animals. But he did not stop with observation. By comparing different animals and thinking about them he was able to recognize likenesses and differences between various kinds or species. For instance, he distinguished whales and dolphins from fishes, and pointed out the family likeness of the domestic pigeon, the wood pigeon, the rock pigeon, and the turtle dove.

His famous works on "The History of Animals," and "The Parts of Animals," show a knowledge of five hundred living forms. In these books he also reviewed the work of former natural scientists. By doing this he stood on the shoulders of the past, but his great learning and originality gave also a new character to everything that had been done before.

Although there is not enough space here to point out other contributions made by Aristotle, it is interesting to know that one of his works had an influence on Columbus. Aristotle's observations of the heavenly bodies had led him to decide that the earth was a round globe. However, he thought it much smaller than it is, and he wrote: "It seems, therefore, not incredible that the region about the Pillars of Hercules [Gibraltar] is connected with that of India and that there is only one ocean." These words helped Columbus to believe that he could reach India by sailing westward from Spain.

Of course errors have been found in the conclusions reached by Aristotle. It was not even possible for him to work out an entirely satisfactory classification of all the varieties of animals. Probably his greatest contribution to science was the spirit of curiosity and inquiry which he turned toward everything about him. He advised investigators to make sure of the facts before seeking the explanation of the facts. Because he, himself, was the greatest investigator of ancient times, he has been given the title, "The Father of Biology."

ARCHIMEDES

(287–212 B. C.)

ARCHIMEDES is sometimes called the "wizard of antiquity" because he gave the world so many practical inventions. For instance, he invented the compass which gave the sailors courage to sail the far seas. He also discovered some of the most important laws of physics, geometry, and engineering. (You will want to read about him in Volume II, pages 5, 14, and 35.)

COPERNICUS

(1473–1543)

COPERNICUS was one of the greatest scientists of the ages. He contributed the theory — which is called by his name — that the sun is the center of the universe and that the earth and planets revolve around it. He studied for thirty-six years to confirm his belief. Even when he was sure that he was correct, he did not publish his book, "The Revolution of the Heavenly Bodies," because he knew that it would be received with ridicule and that he might be persecuted for his statements. The book was printed just a few days before his death when he was seventy years old. (You will find more about him on pages 6 and 60 of this volume.)

THE FOUNDER OF MODERN ANATOMY

VESALIUS (1514–1564)

ANDREAS VESALIUS was born in Brussels, Belgium, in 1514. When he was only a boy, his particular interest in anatomy led him to dissect birds, rabbits, dogs, and other animals. He studied medicine for three years in Paris and then went to the famous university at Padua in northern Italy where it was possible to study anatomy by practical dissection. Nearly everyone at that time considered it wrong to cut up dead bodies. For that reason he had often had to run great risk in finding any which he might dissect.

In Padua his eagerness to see the facts of anatomical structure with his own eyes showed that he was more of an investigator than any of the other student doctors. Therefore, immediately after receiving his degree of Doctor of Medicine, he was placed in charge of the teaching of anatomy. His teaching was different from those before him. The actual dissecting had usually been left to the unskilled barbers, but Vesalius felt that only with "his own hand" could he show his students the secrets of the human frame.

Up to this time Galen, the great physician who lived in the second century A. D., had been considered the authority in anatomy. Vesalius had studied the works of Galen, and at first he sought to illustrate in his own dissections what Galen had said. However, he found that oftentimes his dissections disproved Galen's statements. In the end, he cast Galen's writings aside and taught only what he himself had seen and what he could make his students see. Students flocked to his lectures. It is said that often five hundred would be waiting to listen to him.

After five years of tireless work in Padua, at the age of twenty-eight, he was able to give to the world his "Great Anatomy." In this book the structure of the human body is carefully described and the different parts are illustrated by beautiful and accurate wood engravings, drawn by one of the pupils of the great artist Titian. Here, Vesalius pointed out that Galen had made many mistakes because he had learned his anatomy from the bodies of animals. For instance, Galen had described the lower jaw bone as composed of separate bones as it is in dogs and other lower animals. Vesalius showed that the jaw bone in man is a single bone.

Although this book laid the foundation for structural studies in biology, many people were displeased with it. Most of the doctors thought it wrong to suggest errors in Galen's work; the Church disapproved of dissection. So great was the criticism in Padua that Vesalius went to Spain to become the physician of Charles V. Here he stayed for almost twenty years. However, the Church continued to look on him with disfavor. Finally, when he was dissecting a Spaniard who had recently died, the bystanders insisted that they had seen the heart throb. The man must have been alive they said. This gave the enemies of Vesalius an opportunity to bring a complaint against him to the judges of the inquisition. They would have condemned him to death had not the king persuaded them to send him on a pilgrimage to Jerusalem instead. Vesalius went to Jerusalem and was on his way back to Padua to occupy again the chair of anatomy, which had been offered to him, when he was taken ill. The sailors put him ashore on the island of Zante, one of the Ionian Islands, and there, at the age of fifty, he died.

Although Vesalius made errors in his great study of anatomy, it must be remembered that pioneers in any new way of thinking always have the most difficult task. The important thing is that he reëstablished the scientific method of finding the truth by investigating the facts. Further progress was thus made possible. The influence of his great book is said to have transformed the practice of surgery. For this reason he deserves to be called the "founder of modern anatomy."

HARVEY

(1578–1657)

WILLIAM HARVEY was the great English physician who discovered the circulation of the blood. (You will find the story of his discovery in Volume X, page 327.)

LAMARCK

(1744–1829)

LAMARCK is regarded as the chief forerunner of Darwin. As a boy he had no particular intention of becoming a scientist. His father wanted him to go into the church. He wanted to become a soldier. On the death of his father, when young Jean Lamarck was only seventeen, he ran away to join the French army which was campaigning in Germany. During his first engagement, he was so courageous that he seemed destined for a military life. However, in sport one day the glands of his neck were injured so seriously that he had to return to Paris.

In Paris he began the study of medicine and natural science while he supported himself by working as a bank clerk. After finishing his college course, he worked almost entirely in the field of botany. But when he was fifty years old, he was asked to take a position as professor of Zoölogy at the Museum of Natural History. Here, he was impressed with the resemblances in animals and the difficulty of separating one distinct form or species from another. It seemed to him that animals might be changed by living under different conditions just as plants are.

In his book, "Zoölogical Philosophy," he suggested, for instance, that the long neck of the giraffe might have been gradually developed by the animal's constant effort to obtain food beyond its ordinary reach; while on the other hand, the mole might have lost its sight because it had no occasion to use its eyes. These were new ideas and it took courage and independence to state them. Most of the other scientists laughed at his suggestions, but he could not keep still about what he thought was the truth. Lamarck served science by observing more than did the other zoölogists of the time. (He may be seen in the group in Volume II, page 35.)

Courtesy of National Academy of Sciences

DESCARTES

(1596–1650)

RENÉ DESCARTES was a great French astronomer and mathematician. However, his chief service to science was not in discovering new planets but in showing men that the search for truth was one of the most important things in the world. In the seventeenth century when he lived, nearly everyone thought it was wrong to doubt anything which had been taught. You remember how Galileo had to suffer because he said that the earth moved around the sun.

Descartes said, "It is not true to say we know a thing simply because it has been told us." This attitude influenced science, for scholars began to see that they could trust only those theories which were based on facts and careful experiments. They saw, too, that it was far more honest to *doubt* than to be *perfectly sure* without complete proof. To-day any great scientist follows Descartes' rule; he never pretends to know anything for certain, until the reasons for his belief are so clear that they cannot be doubted.

NEWTON

(1642–1727)

ISAAC NEWTON helped to perfect the Copernican theory of our solar system. He showed that the law of gravity explains why the earth and the planets revolve around the sun. This universal law working through space keeps the sun in control of the planets and prevents chaos. (You will want to read more about Newton on page 30 of this volume.)

LINNÆUS

(1707–1778)

LINNÆUS, the great botanist, was born in Rashult, Sweden. His father was a poor clergyman, who hoped that his son would also become a preacher in the Swedish church. However, the boy did so poorly in his studies that the father was discouraged and decided to apprentice him to a shoemaker. The trouble was that young Linnæus had been collecting botany specimens instead of studying his school books. A friendly doctor knew this and told the father that his son should study medicine.

The father saw the wisdom of the doctor's suggestion, but he could scrape together only forty dollars to start the boy at the university. For eight long years the young man struggled with poverty before he finally took his medical degree. Almost immediately thereafter, he brought out several books about plants which showed him to be the most original botanist in Europe. He traveled in England, France, and Holland, and then returned to the University of Upsula, Sweden, as professor of botany.

Here he began his great work of classifying all plants into one great system.

The important point in his classification was that he gave a second or specific name to every plant. For this reason it is called the "binomial" system of names. He started by dividing up the vegetable kingdom into "families," such as the rose family, the mint family, and the lily family, putting together those plants which resembled each other in a general way. Each family he separated into "genera," or smaller groups, such as apple, rose, strawberry, sage, mint, and balm. Under every genus were included all the various kinds of plants in that particular group. Thus in the rose genus were put the Scotch rose, the dog-rose, the cinnamon rose, the eglantine, and others. Each genus was given a definite Latin or Greek name and every species under it had an additional name as well. Thus the Scotch rose was *Rosa spinosissima;* the dog-rose, *Rosa canina;* the cinnamon rose, *Rosa cinnamomea;* the eglantine, *Rosa rubiginosa*, and so on. These names of the species were intended to be descriptive of the plant or to tell the locality in which it grew. The two names, under this binomial system, thus placed every plant definitely in its particular species and genus and also indicated at least one of its important characteristics. This general plan of the classification and naming of plants was so much simpler than the old way that it was soon taken up by all botanists and zoölogists and used in describing all the new species which were discovered as time went on. To-day these scientific men, whatever language they speak, can all understand what plants and animals their friends are talking about, because no matter how many common names any species has, its two Latin ones are recognized all over the world.

LAVOISIER

(1743–1794)

ANTOINE LAURENT LAVOISIER, who lived in Paris during the last half of the eighteenth century, is called the "father of modern chemistry." At college he was a brilliant student in mathematics and science. When he was only twenty-one, he received a medal from the Académie des Science for an essay on the best way of lighting the streets of Paris.

His particular service to chemistry was in showing that when a metal or other substance is burned in the air, it takes oxygen out of the air to unite with itself and so is changed chemically. Heretofore, chemists had not understood this change. They thought that a mysterious element called "phlogiston" was given off when materials were burned.

Lavoisier experimented with burning different kinds of metals until they turned into powder. He puzzled about the fact that this powder weighed more than the metal did before it was burned. Then, he discovered that if he burned the metal in a closed space, the air lost the exact amount of weight which the metal gained. Therefore, he could prove that a burning substance takes a certain gas, which he called oxygen, out of the air instead of putting something into it. This meant that there could be no such thing as phlogiston and gave an entirely new theory of chemical change.

In his book, "Elements of Chemistry," Lavoisier explained clearly how such chemical changes took place and gave directions to show students how they could perform his experiments for themselves. He also classified all that was known about chemistry up to that time. In place of the vague, uncertain terms, such as "liver of sulphur," "mercury of life," and "salt of many virtues," which had been brought over from the time of alchemy, he gave definite, meaningful names. His book is said to have been epoch-making because it made chemistry an exact science, that is, one which is based on definite rules like astronomy and physics.

Chemists were just beginning to see how important Lavoisier's work was when a very tragic thing happened. It was the time of the French Revolution. Lavoisier had held a government position as farmer-general, and all the farmer-generals were condemned to death. Although his friends tried to save his life on the grounds of his great service to science, the only answer made by the government was: "The Republic has no need of learned men." Thus, at the age of fifty-one, when he was eager to carry on further studies, the father of modern chemistry was guillotined.

DALTON
(1766–1844)

JOHN DALTON has been described as a lawgiver of chemical science. His interest in chemistry came about in an interesting way. When he was only fifteen, he went from his home in Cumberland to teach in Kendall, a town in the Lake district of England. In this region there is a great deal of rainfall, sometimes more than forty inches a year. Young Dalton thought it would be a great service to the farmer, to the sailor, and to all men if it were possible to predict the coming weather. Therefore, he constructed a rude sort of apparatus consisting of rain-gauges to test the amount of waterfall.

From this simple beginning he went on to take two hundred thousand observations regarding the weather. These formed the basis of some of the greatest discoveries in meteorology, — the science of weather forecasting. But there was another important result.

In connection with his study of rainfall, Dalton became interested in the process of evaporation. He thought about the small particles of water vapor in the air. It had already been discovered that water was composed of the two elements, hydrogen and oxygen. Now Dalton tried to figure out why hydrogen and oxygen should combine as they do to make water.

In seeking an answer to this question, he turned to the investigation of the way in which other elements unite. You remember that Lavoisier had shown the importance of weighing accurately the elements of which substances are composed. Dalton also weighed elements until he saw that there were definite laws of chemical combination which all elements obeyed. By working out the *relative* weights of the smallest particles, or atoms, of the different elements, he was able to show that any chemical compound always contains the same elements combined in the same proportion. For instance, the familiar chemical symbol H_2O means that two atoms of hydrogen have combined with one atom of oxygen to make a molecule, or compound atom of water.

The investigations of Dalton threw a new light on the composition of matter and the relations of the elements to each other. His laws developing the atomic theory are said to have brought modern chemistry out of chaos into order. (You will find him in the group on page 35 of Volume II.)

LAPLACE
(1749–1827)

"WHAT we know is so little, what we do not know is so immense." These words were spoken by Pierre Simon Laplace, one of the world's greatest astronomers.

Laplace was the son of a poor French farmer. As a lad he showed such unusual ability in mathematics that some rich neighbors helped him to get a good primary education. When he was twenty, he was made a teacher of mathematics in a school in Paris. From the study of mathematics, he went to a study of the stars and planets. His theory of the way in which our solar system was formed is called the "nebular hypothesis." Although astronomers, now, do not believe that it is correct, it is very interesting and you will like to read the explanation of it on pages 65 and 66 of this volume.

His most important work lay in proving beyond doubt that Newton's theory of gravitation would account for all the movements of the heavenly bodies. According to that theory, every planet attracts every other planet, and this attraction causes certain changes in the path each takes round the sun. Astronomers can work out by mathematical calculations just what each planet will do. But at that time they were puzzled because Jupiter and Saturn did not seem to obey any general law.

Laplace carried his calculations farther than any other astronomer and at last proved that these two planets do obey the law of gravitation. Their seemingly irregular movements are caused by the fact that Jupiter travels two and one-half times round the sun while Saturn travels once. This makes Jupiter overtake Saturn at certain periods. Of course, when this happens, each pulls the other out of its proper path. But since they never meet each other in quite the same place, they finally right themselves and after an immensely long time return to their old positions in the sky as the other planets do.

Laplace's calculation of this movement is called the "long inequality of Jupiter and Saturn." He also worked out a problem in regard to the motion of the moon which had been bothering astronomers. And so at last they were sure that all planets moved in a certain regular order and that Newton's theory of gravitation was the correct one.

CUVIER

(1769–1832)

FROM ancient times people have been interested in the stars, but it was long before they realized that there was a world of buried ancient life almost beneath our feet. This world was brought to the attention of men by Cuvier.

Georges Cuvier was born in southwestern Germany. His parents had little money to spend on his education, but he had shown such brilliancy as a lad that Prince Charles of Württenburg gave him a free education at the University of Stuttgard. Here all his spare moments were given to reading books on natural history and to drawing plants and animals. After finishing college, young Cuvier studied marine animals on the shores of Normandy for several years. Then he was offered a position in Paris in the department of anatomy at the Museum of Natural Science, where Lamarck was carrying on his study of zoölogy.

Cuvier's first great work was to collect all the facts that were known about comparative anatomy — that is the science of the structure of the parts of animals and the relation of these parts. Then, adding to these facts a great many of his own observations, he worked out a new classification of the whole animal kingdom. All the animals he divided into four great branches: the *vertebrata*, or animals with backbones; the *mollusca*, or soft-bodied animals such as snails; the *articula*, or animals such as crabs, spiders, bees, and ants, whose bodies are composed of movable parts, the hardest outside, and joined or articulated together; and the *radiata*, or animals whose parts are arranged about an axis, such as starfish.

While Cuvier was carrying on this work, the laborers in a quarry near Paris dug some huge bones out of the rock. Such bones had always been a puzzle to anatomists because none of them seemed to agree with any living animal. Most people had thought that they belonged to a race of giants of former times. Cuvier, however, soon pointed out that they were bones of elephants of an unrecognized species. By the beginning of the nineteenth century he had collected bones of about twenty-five kinds of animals that he said were different from any now living on the globe. This was an astonishing announcement, for it meant that ages ago there had been strange huge creatures roaming over the world, who had lived and died and been buried in the deposits now forming part of the earth's crust.

All these animals, among them the hairy elephant which Cuvier named the mammoth, are described in a famous book, "Ossements Fossiles." This started the study of animal fossils, now called the science of "vertebrate paleontology." And to Cuvier we owe the knowledge that each part of an animal agrees with the other parts so perfectly that from a few bones an anatomist can tell exactly what all the other bones must be, and can even make a restoration of the animal itself. In a museum of natural history you can see the skeletons of these huge beasts, the bones of which have been fitted together by a skilled anatomist.

GAUSS

(1777–1855)

KARL GAUSS was born in Brunswick, Germany. His father, who was a bricklayer, saw no reason for educating his son. In fact, he felt that his family needed the wages which young Karl might earn as a laborer; but the reigning duke of that region helped the boy to go to the University of Göttingen. Here he graduated with high honors in mathematics.

Many of Gauss's achievements were in the field of pure mathematics. For instance, he solved the problem of dividing a circle into seventeen equal arcs by simple geometrical principles. This was the first time that the ancient Greek knowledge had been extended in that field.

In astronomy he won fame by inventing a new method of calculating the positions of

heavenly bodies. It had happened that a new planet, Ceres, had been discovered on January 1, 1801, but after a few weeks the astronomers lost sight of it. Gauss, however, calculated the path which this planet should take so accurately that by the end of the year it was rediscovered in the position his figures had indicated.

He is considered the founder of the mathematical theory of electricity, and he also deserves credit for being one of the first actually to use a system of telegraphing. In order to communicate with each other rapidly and easily, he and another scientist had set up a wire connection between two observatories. Their system of signaling by sound was highly successful.

HUMBOLDT

(1769–1859)

ALEXANDER VON HUMBOLDT was born in Berlin and educated at the University of Göttingen. He became one of the greatest travelers of the early nineteenth century.

His most important voyage took him to America where he explored for six years. Starting in northern South America he traveled up the valley of the Orinoco to its source. From there he went down through Ecuador, Peru, and northern Bolivia, regions whose geography was almost unknown. He discovered the source of the Amazon, noted the heights of the mountains, the climates, and the mineral and metal resources. Then he traced everywhere the different species of plants, observing which grew in lowlands and which in highlands, even up to the height of 20,000 feet on the Andes. This led him to try to find out why certain plants will grow only in certain areas.

On this long voyage Humboldt started another important task. This was finding out the climate of different parts of the world and tracing out lines of equal heat over the globe — "isothermal lines" they are called — in order to show which countries have the same average heat. He also tried to give the reasons for different climates. For instance, he explained that Greenland is much colder than Lapland, although the same line of latitude crosses them both, because a cold current from the North Pole flows past Greenland, while the warm Gulf Stream crosses over from the Gulf of Mexico and warms the shores of Lapland. A systematic study of climate variations had never before been attempted. Humboldt's work laid the foundation for the science of climatology.

ALEXANDER VON HUMBOLDT

Another important trip for observation took him into Siberia as far as the Yenesi Valley. And now at last, on his return to Germany, he was ready to start his great book, "Cosmos," or "The Universe." In this he brought together all the information that he had collected: the study of the surface of the globe, mountains, and rivers; the climate of countries; the different winds that blow; and the way in which the races of men, as well as plants and animals, are distributed over the earth. These facts and many, many more, which Humboldt had collected, help to make geography a living subject. The four volumes of "Cosmos" were translated into most of the modern languages and made a great impression on all students. They saw, as never before, that the universe was one great whole and that there was something interesting in every part of it. (Humboldt may be seen in the group in Volume II, page 35.)

LYELL

(1797–1875)

SIR CHARLES LYELL is called the founder of modern geology because he taught men to read the true history of the earth. When he began his study, men knew that the earth had not always been just as it is now. They thought, however, that some extraordinary violence of nature, such as earthquakes which shook the whole world and vast floods had carved out our present rivers, valleys, and mountains.

Lyell started by collecting information about all the changes which are going on constantly over the earth. He studied not only earthquakes and floods, but also such a simple thing as the fall of rain and how it wears away the land little by little. He calculated the amount of mud carried by great rivers like the Mississippi and the Nile and deposited in the sea at their mouths. His careful observation told him that the falls of Niagara were slowly but constantly moving upstream. These and many, many other changes which were taking place all over the world Lyell studied with great accuracy. He was finally able to prove that the changes in the crust of the earth have been brought about gradually through long ages by the same causes which are in action now. (He may be seen in the group in Volume II, page 377.)

AGASSIZ

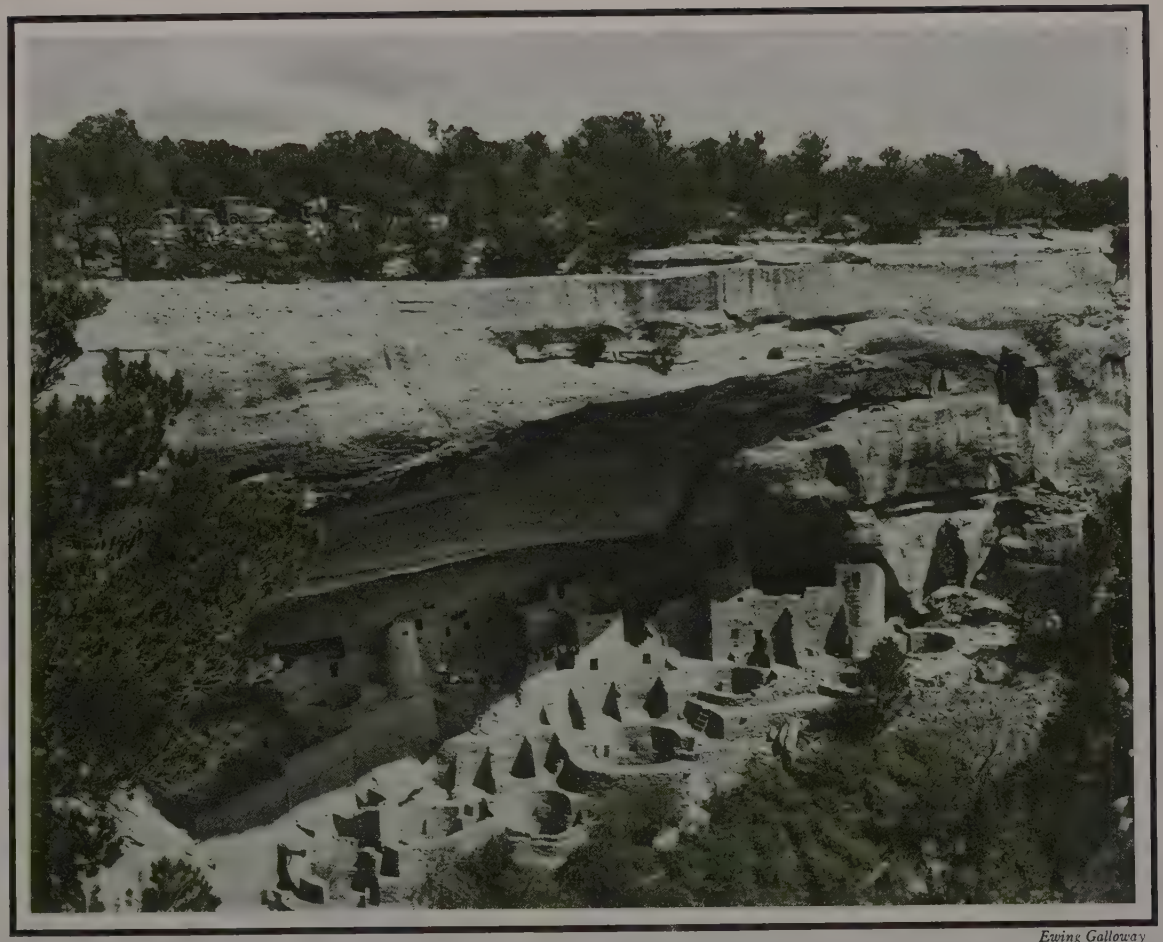
(1807–1874)

"IF you study nature in books, when you go out of doors you cannot find her." This was the friendly warning which Professor Louis Agassiz, the naturalist, gave to his students at Harvard College. He himself studied nature so well that he made one of the greatest scientific discoveries of the nineteenth century. In his native country, Switzerland, he had been fascinated by the great rivers of ice, or glaciers, which creep slowly down the valleys in the Alps carrying with them sand, stones, and sometimes huge pieces of rock. He noticed that rocks over which a glacier had moved were polished

LOUIS AGASSIZ

and grooved by the rough stones and sand frozen into the bottom of the ice. Then to his surprise, he found that mountains in regions now too warm for glaciers were marked in the same way. Not only in Switzerland, but also in all the northern countries of Europe and of North America were found these markings and other unmistakable signs of glaciers. His observations proved that the temperate parts of our northern hemisphere must have been intensely cold at one time and that "great sheets of ice resembling those now existing in Greenland once covered large parts of these countries." This period of cold is called the "Glacial Period."

Although the world remembers Agassiz as a great scientist, our country also remembers him as one of its greatest teachers. He became a professor of zoölogy at Harvard College in 1848, and for more than twenty-five years trained young naturalists to carry on his favorite studies. He is buried in the beautiful Mount Auburn Cemetery where later his friends, Longfellow, Holmes, and Lowell came to rest.



Ewing Galloway

THE CLIFF PALACE AT MESA VERDE, COLORADO

Buildings of an old civilization which has long since disappeared from this continent.

PEOPLES OF THE WORLD

A STUDY OF MAN
PREHISTORIC, HISTORIC, MODERN

ANIMALS BEFORE MAN, By Hervey W. Shimer

EARLY MAN, By Hervey W. Shimer

PEOPLES OF LONG AGO, By Hervey W. Shimer

- Egypt
- Ur, the City that Saw the Flood
- Troy, a Cross Section of History
- Pueblo Bonito, the Oldest Town in North America
- The Mayas
- The Mound Builders
- Modern Cave Dwellers in North Africa

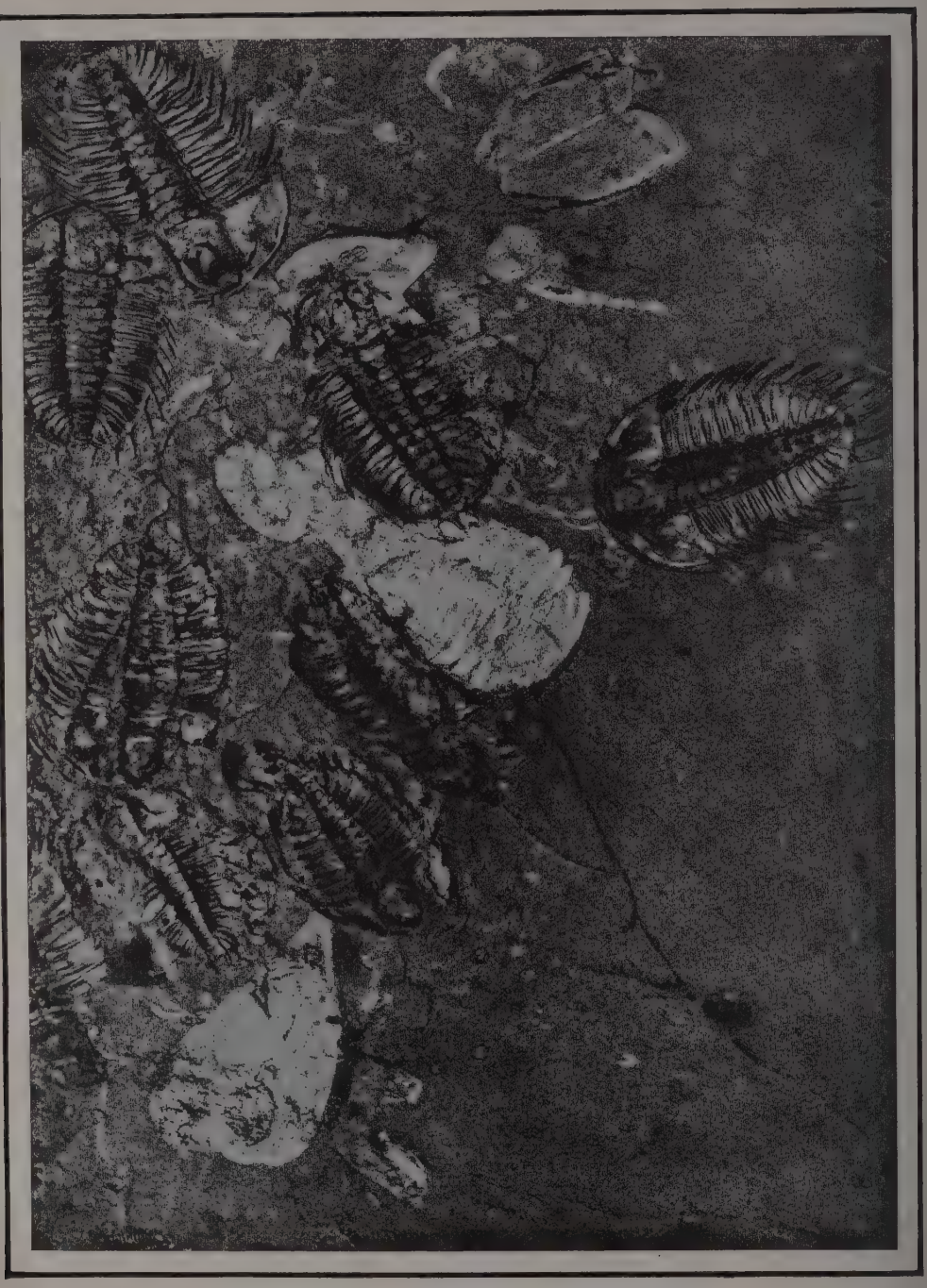
INTERESTING PEOPLES

- The Wild Bushmen
- Pygmies
- The Fuzzy-haired Papuans
- The Polynesians
- The Maori of New Zealand
- The Ethiopians
- The World-wandering Gypsies
- Bedouins
- Our Neighbors in South America
- Lapps, the Smallest People in Europe
- The Changing Chinese
- The Clever Japanese
- People of India

THREE LEADERS OF THE NEW ORDER

- The Young Patriot — José Rizal
- Sun Yat-Sen
- Mahatma Gandhi

THE INDIANS OF AMERICA, By Edwin Willard Deming and Therese O. Deming



ANIMALS OF THE LONG-DISTANT PAST, BURIED IN THE ROCK

Ancient Relatives of the Lobster, called "Trilobites."

See page 277.

Courtesy of American Museum of Natural History

DIPLODOCUS (See page 281.)

ANIMALS BEFORE MAN

LONG before man appeared on the earth, there were animals living here — very tiny creatures and giant animals, some like those of to-day, some very different, and all interesting both in themselves and because they are the ancestors of the present animals.

Since no man was alive on the earth to see them, the question may well be asked as to how we know about them. To find that out, let us walk on the beach of a river, lake, or ocean.

HOW LAND IS BUILT IN LAYERS

This beach may be made of mud, sand, gravel or larger pieces of rock. Mixed with these we may nearly always find shells, more rarely the bones of fish or land animals. Mud and sands of various kinds are being laid down to-day in every ocean, lake and swamp, where dead shells and bones are being covered by them. It was thus yesterday and all the yesterdays of the past history of the earth. As these muds and sands become more and more deeply buried by the material piled upon them they gradually harden into solid rock. At times during the many millions of years of this history, mountains and plateaus have been shoved up out of the ocean. The streams have slowly cut deep canyons into them, thus bringing to view edges of an ancient seabeach, or lake, or swamp; and man may now gather shells and bones of the animals which lived during the yesterdays of earth history.

The deeper layers of earth will show the earlier animals, those higher or nearer the surface will show the later forms.

WHAT WE FIND

In the lower rocks, that is, those laid down as muds or sands during the earlier times of earth history, no bones are found, only shells, corals, and other low forms of animal life. These animals, which we call "invertebrates," meaning "animals with no backbone," are all different from those living to-day.

It was a step up in the scale of life when bones appeared. In higher rocks a few are found; still higher they become more abundant. At first there are only bones of fish; later, animals appear which can live in both land and water. They are called "amphibians," from the Greek words *amphi* meaning "both" and *bios* meaning "life." They are tadpoles when young and live in water

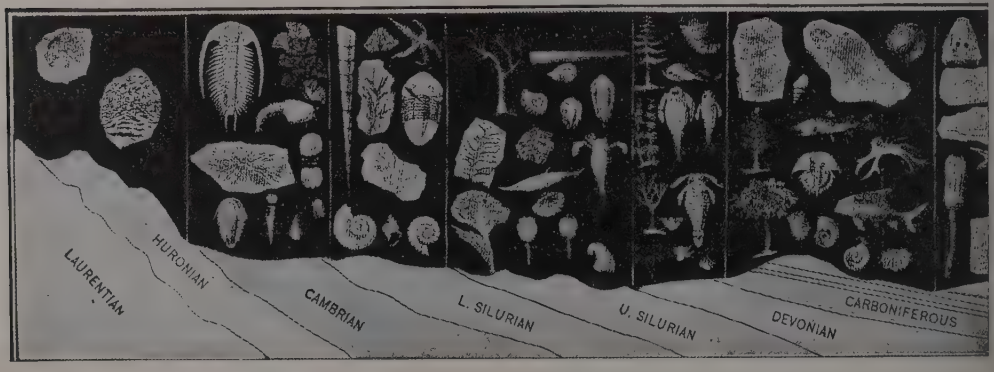
ERAS	Animals In the order in which they appeared on earth
ARCHEOZOIC . . .	**Backboneless Animals.** Mostly with external skeletons.
PALEOZOIC	**Fish.** First animals with a backbone.
	Swamp Dwellers. Amphibians, at home in water and on land; also, lowly insects.
MESOZOIC	**Reptiles.** Both plant eaters and fish eaters; both water and flying reptiles; also, birds with teeth.
CENOZOIC	**Mammals.** An immense class, varying in size from the mouse to the elephant.

like fish. When they are fully grown they leave the water and come up on land, although usually staying where it is damp. In higher and higher rocks the remains or fossils of fish and amphibians are found, but in addition there also appear the true land animals. Mounting by layers they appear in the order in which they appeared on the earth: first reptiles, then birds and mammals, and finally man.

BACKBONELESS ANIMALS, EARTH'S RULERS FOR A BILLION YEARS

In the early days of earth history there were no land animals. It is hard for us to imagine such a world. No birds, no insects in the air, no animals, not even a bug, roaming over the ground, not even a tree to climb into, nor grass to hide under. Most animals in existence at that time lived in the ocean, a few in rivers or lakes. Yet even in the early part of the Paleozoic Era, if we may judge by the way the rocks are crowded with fossils, the oceans must have had as many animals in them as they have to-day. There were not, however, so many different kinds.

These early creatures ate their food and lived their lives much as ocean-dwelling animals do to-day. Most of them fastened themselves to rocks or were partly buried in mud at the bottom of the more shallow parts of the ocean. These, which included corals, caught and ate such food



FORMS OF LIFE BY PERIODS, FROM THE SIMPLEST CREATURES

as waves and currents carried to them. Others, especially those ancient relatives of the lobster called "trilobites," crept over the bottom or grubbed through the mud searching for food. Still others, such as the ancestors of our chambered nautilus, swam more or less freely, while at the surface floated the jellyfish just as they do now.

Among the animals in the world to-day, we see two kinds of skeletons to which the muscles are attached. The lower animals, like the oyster and the crayfish, have an external skeleton; the higher animals, like the fish and the bird, an internal one. The animals with an external skeleton are usually slow-moving and sluggish; those with an internal one are as a rule quick and swift in their movements.* In the early days of earth history, with the exception of a few animals like the jellyfish, all had an outside skeleton covering the soft flesh of the body more or less completely. This skeleton was in most animals made up of lime, as it is in the oyster now. In others, as in the trilobites, it was chitin, the same material that is used by the lobster and the beetle. None had an internal skeleton of bone. Animals possessing a backbone are called "vertebrates" and those without it are "invertebrates." The prefix "in" means "not," and thus invertebrate means "not a vertebrate," that is, an animal having no backbone.

This state of affairs, when no animal in existence could boast the possession of a backbone, lasted for upwards of a billion years. Thus throughout more than one half of the time from the appearance of life upon earth to the present, all the animals were invertebrates, and they were even much simpler invertebrates than those living to-day.

FISH, THE EARLIEST ANIMALS WITH A BACKBONE

Sometime during the middle part of the Paleozoic Era some new and very wonderful creatures appeared upon the earth. These were the fishes, the first animals with a backbone. Changes quietly taking place in muscles and skeleton had produced the body of the first vertebrates.

The fish body is built upon an entirely different plan from the body of the invertebrate animal. It has an internal skeleton, the most important part of which is the backbone. The muscles are fastened to this internal skeleton; that is, the muscles are upon the outside of the skeleton. Up to this time animals had had their muscles attached to the inside of their external skeleton, as do the oyster and the crayfish to-day. Since fish did not have a hard shell covering their body to protect them, they had to develop speed to escape their enemies. This speed, together with their sharp teeth, would enable them to get food. Fish seem to have appeared first in rivers, but they soon became very abundant both in rivers and in oceans.

MESOZOIC CENOZOIC

TO THE ADVANCED FORMS OF TO-DAY

* See "To Move or Not to Move" and "Animals in Armor," Volume Ten, pages 19–20 and 32–37.

BRIDGING UNTOLD AGES

Above: Amphibians and insects which lived in the coal swamps of North America in prehistoric times. Below: Their present-day descendants, the frog, the toad, the newt, the dragonfly, and the cockroach.

THE SWAMP DWELLERS

During the latter portion of the Paleozoic Era large swamps existed in various parts of the world. In these the leaves and twigs falling from the trees into the water gradually changed into a black mud which in later ages became solid coal. And it was in these coal swamps that two widely different groups of animals took their first step upon land. These were the amphibians and the insects. Amphibians are best known to-day by the frogs, toads, and salamanders. During the later Paleozoic the amphibians had long tails and were thus like salamanders in this respect. The salamanders of to-day, such as the newt, are about a foot long. In these Paleozoic coal swamps the skull alone of one species was four feet long and almost as wide. Since the mouth opened to nearly the full width of the skull, he must have been a formidable-looking animal.

Among the insects living in these late Paleozoic swamps were the cockroach and the dragonfly. Both, judging from their fossil remains in the coal shales, were very abundant in these swamps. The descendants of these are now, as they were in the distant past, found in moist places. To-day we see the dragonfly darting about a pond or skimming low over its surface, for it must drop its eggs into water to ensure hatching. The cockroach lives to-day in damp, moldy places, under boards, in sewers or beneath sinks. He hides by day and feeds by night. When we watch a dragonfly wing its way across a pond or a cockroach run beneath a log or scuttle behind a water pipe, we realize something about the persistence of a habit. Here is a habit of living near ponds or in moist places which

Courtesy of the Koppers Company

A PALEOZOIC SWAMP

has persisted for upwards of 300 millions of years.

Man is at times proud that he can trace his ancestors back to the early settlement of America or even, it may be, back to the time of William the Conqueror, 1066 A.D. Yet, compared with insects, what right has man to be proud simply of length of ancestral line? The cockroach sitting beneath the kitchen sink may point his antennæ at the coal in the scuttle and say, "When that was being laid down in its ancient swamps my family was already in existence." My boast of ancestry may be superior to that of the cockroach or dragonfly only if each succeeding descendant along my ancestral tree rises above the preceding one in true nobility of thought and action. It is only if we live up to the thought of *noblesse oblige*, with good birth putting upon us the obligation to attain to the nobility of our ancestors, that we rise superior to the boast of the cockroach.

REPTILES, EARTH'S RULERS FOR TWO HUNDRED MILLION YEARS

To-day when the word reptile is used we think at once of snakes and lizards. These are our most common reptiles. But during the Mesozoic Era there were many other kinds. While some lived upon land, others lived in the waters of rivers and oceans, and still others spent much time soaring about in the air looking for food. Reptiles were so very abundant that the Mesozoic is called the "Age of Reptiles." They first appeared upon earth during the closing stages of the Paleozoic Era.

DINOSAURS, THE TERRIBLE LIZARDS

The land reptiles of the Mesozoic included, among others, crocodiles, turtles, lizards, and most abundant of all, the dinosaurs. The word dinosaur means "terrible lizard." Some of these were the largest land animals that ever lived.

Courtesy of American Museum of Natural History

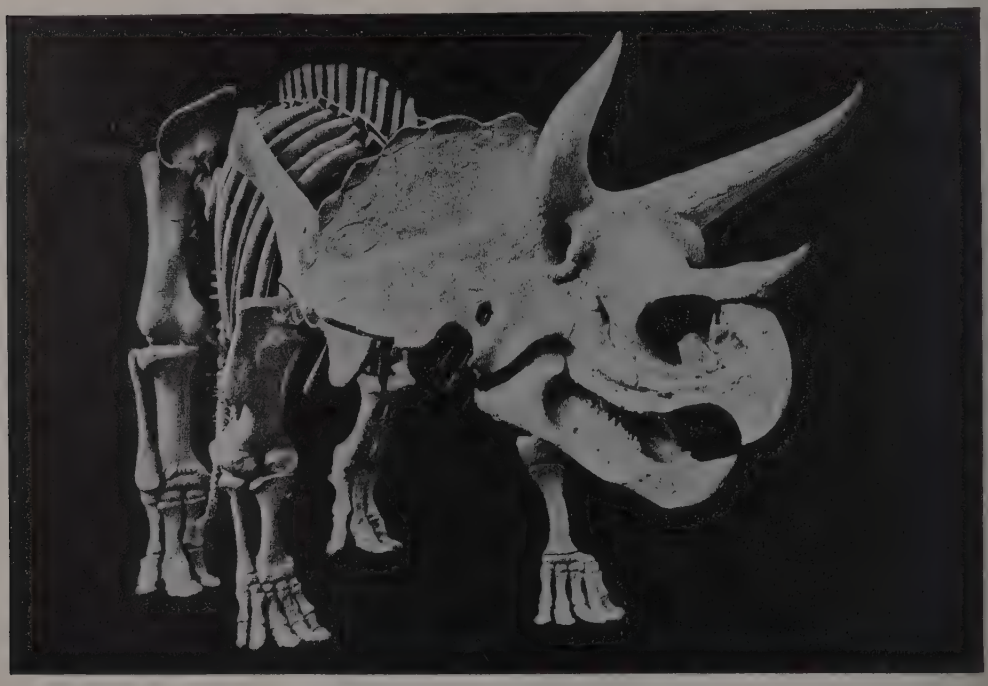
BRONTOSAURUS — A ROCKY MOUNTAIN PLANT EATER OF THE LONG-DISTANT PAST

It had a very small snake-like head, a long, flexible neck, and pillar-like limbs like those of an elephant.

To-day all reptiles except some turtles feed upon animals. This animal food may include such items as insects, toads, birds and mammals. During the Mesozoic Era very many dinosaurs were plant feeders, and it is among these feeders upon plants that the largest of all known land animals are found. In any class of animals it is those groups which live upon plants that attain the largest size, for such food is abundant and may be easily obtained. Among mammals the grass and twig-eating elephant, giraffe and hippopotamus are much larger than the flesh-eating lion and tiger. Moreover since flesh eaters must chase and capture their food, they must be able to move quickly; and heavy and massive bodies cannot do this.

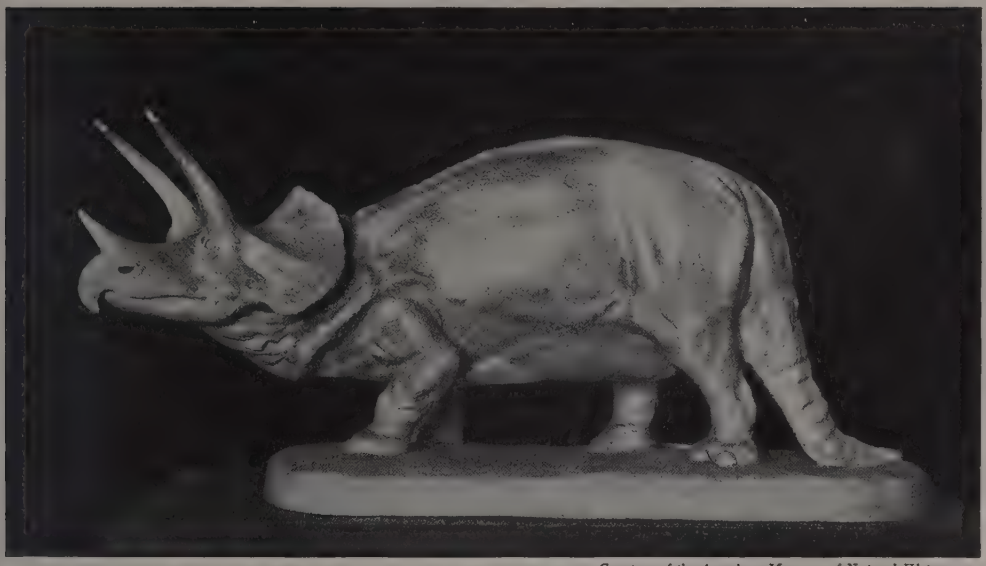
PLANT EATERS

One of the largest of these dinosaurs (plant-eating reptiles) was Brontosaurus. This animal lived in the Rocky Mountain region of North America when that region was low and swampy, millions of years before it was raised into the present mountains. Brontosaurus had a length of 67 feet and a height at the hips of about 15 feet. It had a snake-like head, a long, flexible ostrich-like neck and pillar-like hind limbs somewhat like those of an elephant. In proportion to its body it had the smallest head of any known animal. The weak joints of the limb and foot bones would seem to indicate that it could not have walked much upon land. The animal probably lived in coastal swamps and marshes, where the heavy, solid leg- and foot-bones would keep its body upon the bottom, while its lightly made head and neck could rise above the water surface like the periscope of a submarine. It could thus forage for food upon the branches of trees bordering the swamp or upon the water plants of the bottom. The weight of a living animal is estimated to have been 38 tons. If a comparatively wee animal like a four-ton elephant eats, as we know, 800 pounds of green



THE THREE-HORNED, PLANT-EATING TRICERATOPS

The bones of this skeleton were found buried in the solid rock of the North American Rocky Mountains.



Courtesy of the American Museum of Natural History

THE TRICERATOPS: A RESTORATION

The animal of which the skeleton is shown on the opposite page, as he is supposed to have looked when alive.

fodder and 18 pounds of grain per day, a thirty-eight-ton Brontosaurus should consume at least 7500 pounds of leaves and twigs in the same time. With so small a head the business of eating this amount must have kept it busy. To help grind this immense amount of fodder it swallowed many stones, and must hence have had a gizzard like its cousin, the present-day chicken.

Another North American plant-eating dinosaur of the same general build as Brontosaurus was Diplodocus. It was 20 feet longer, having a length of 87 feet, but was less massive, with a longer and more slender tail.

The bulky Triceratops was another interesting plant-feeding dinosaur that would have reminded us of a very large rhinoceros. This group of reptiles was very abundant in North America during the closing millennia of the Mesozoic Era. It is the last of the hordes of dinosaurs which held all continents in a reign of brute force during the whole of the Mesozoic. It had horns somewhat like a rhinoceros and a sharp cutting beak like a bird or turtle. A common form in North America was 25 feet long and 10 feet high. It had three forward-projecting horns upon its head, and its skull extended backward over its neck as a huge, broad, bony frill.

FLESH EATERS

One of the largest of flesh-eating dinosaurs has been named Tyrannosaurus, the tyrant reptile. The best-known species from North America was 47 feet long and 20 feet high. This is nearly twice the height of the largest African elephant, which stands about twelve feet high. Its numerous pointed and sharp-edged teeth varied in length from three to six inches. It must have walked entirely upon its hind legs since the front legs are so small. When running it apparently used its tail to balance the front part of the body, just as some lizards do to-day. When we think of the strength of an eight-foot-long lion we are inclined to believe that Tyrannosaurus was rightly named the "tyrant." Its brain was minute for so huge an animal, weighing scarcely a pound; and hence it had very little wit. Huge though its body was, the creature was so lacking in cunning that it would probably have been killed in a fight with a lion.

Courtesy of American Museum of Natural History

THE TYRANT REPTILE, TYRANNOSAURUS, CONSIDERING AN ATTACK ON A FAMILY OF TRICERATOPS

WATER REPTILES

Throughout the Mesozoic period, while dinosaurs ruled the land and flying reptiles ruled the air, three great groups of reptiles ruled the oceans. These were the fish-like lizards known as Ichthyosaurs, the Plesiosaurs, with long snake-like necks, and the ancient sea serpents, the Mosasaurs. These reptiles had no easy life, for besides fighting with one another they had to contend with huge fish. One of these enemies was the Bull-dog fish, which had a head the size of that of a grizzly bear, with numerous teeth rising three inches above his mighty jaws.

All reptiles breathe air. When the earliest reptiles became gradually adapted to a land life, they committed their descendants for all time to a similar air-breathing habit. Even those that took to a water life must still have come to the surface to breathe air, just as the whale among mammals must do to-day.

The ancestors of each of these three groups were walking and running land reptiles earlier in the Mesozoic Era. The change from a land life to a water life came about very slowly. It took millions of years for the ancestral land reptiles to become such perfect water reptiles. This was a reversal of the "water to land" process taking place among the vertebrates during the middle and upper Paleozoic times.* At that time some of the fish gradually changed into swamp-dwelling amphibians, and later some of the amphibians into dry-land reptiles. During the 100,000,000 years of the middle and early upper Paleozoic Eras the peculiar, fleshy fins of these fish changed into legs, lungs developed from an outpocketing of the pharynx (the part of the food canal between the mouth and the gullet), and the gills disappeared.

Most reptiles to-day lay their eggs in sand or some other warm place upon land, where they hatch out. The reptile egg has many very minute holes in it. This is to permit the air to enter so that the growing young can breathe. Because of this need for fresh air the egg could not be laid in water. The water reptiles of the Mesozoic Age must thus either have floundered out upon land to lay their eggs, or have kept the eggs within their body until the young had hatched. To-day many lizards and snakes do this and produce their young alive. It is known that some of the ancient reptiles did the same; and it is suspected that all three groups did so. Within the body of one well-preserved Ichthyosaur, seven fossil young Ichthyosaurs are seen. Since these seven are all of the same size and uninjured, it is concluded that they are babies within the mother. They were about ready to be born when the mother died. Within other skeletons eight to ten young specimens have been found. The skeletons of some Plesiosaurs have also been found with small, uninjured young within them, so that it is known that Plesiosaurs also produced their young alive.

ICHTHYOSAURS

Although Ichthyosaurs disappeared from earth 100,000,000 years ago, much is known of their life and habits. Hundreds of complete fossil animals have been found embedded in the solid rock. These rocks, laid down as sand and mud, covered the dead animals and thus preserved them to this day.

In outline they looked like fish. They had a pointed head, no neck, a flattened tail, two pairs of fin-like paddles, and a narrow fold of skin along the back looking like a dorsal fin. Some of the largest reached a length of 30 feet. They had very many short, cone-shaped teeth, which were fine for catching prey but not for tearing it. So they probably swallowed their prey whole. The fossilized remains of food found between the ribs of some specimens, in the place where the stomach was, prove that they lived largely upon squids and fish. They must have been very voracious for in one specimen were found almost 200 of the peculiar cigar-shaped internal skeletons of the squid.

PLESIOSAURS

The reptiles belonging to this group have head and neck like a snake rising from a torpedo-like body. To this body are attached two pairs of strong paddles. The largest Plesiosaur known has a length of 40 feet, 23 feet of which is neck. Dean Buckland compared a Plesiosaur to "a snake threaded through the shell of a turtle"; only in this case the turtle had no shell. Over

* See "Life in Three Zones," Volume Ten, pages 65–77.

PLESIOSAURS, SEAL-LIKE REPTILES ABUNDANT UPON THE EARTH DURING THE MESOZOIC ERA

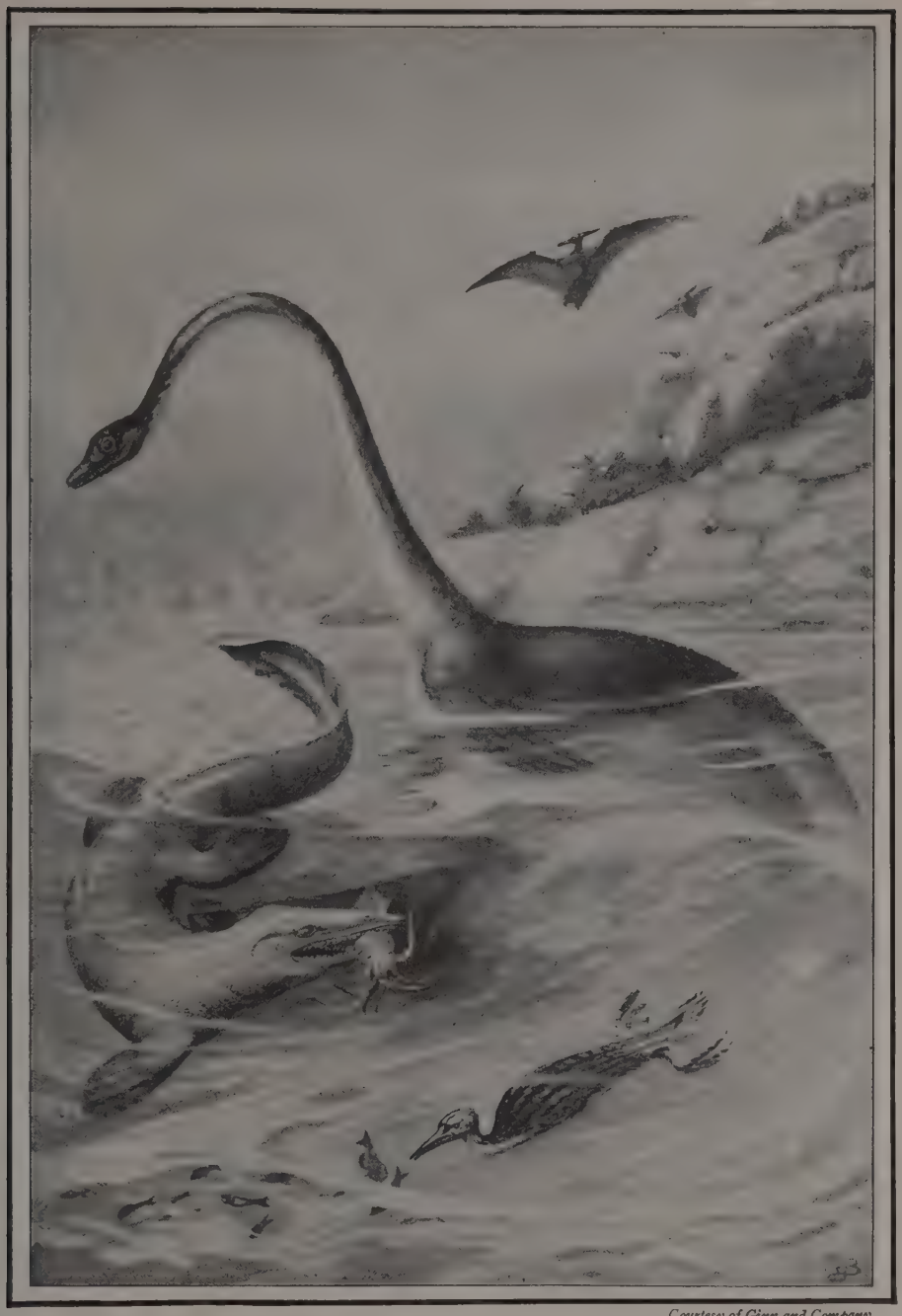
fifty years ago Professor Seeley found within a medium-sized Plesiosaur nearly a peck of smoothly polished, rounded pebbles. All these were very hard and usually were composed of chert, a mineral somewhat like flint. Since that time very many skeletons have been found containing such stones. In one case there was a half bushel of pebbles varying in diameter up to four inches. Because stones are found in the part of the body where the stomach must have been, it is concluded that the stomach was a gizzard, like the stomach of the common chicken. Among the reptiles to-day the crocodile also has the habit of swallowing stones. In this gizzard the stones swallowed by the Plesiosaur would aid in grinding the hard parts of its food. With these gizzard stones are found the bones of fish and flying reptiles and shells much like our present chambered nautilus. The long, flexible neck must have been ideal for picking such shelled animals from the bottom of shallow seas and quickly grasping a flying reptile that flew too near the surface of the ocean.

MOSASAURS

This third group of water reptiles came into existence in the later Mesozoic Age. They were much like the fabled sea serpent of the Middle Ages. As in the snake, the head and long body had about the same thickness. The fully grown animals ranged in length up to 50 feet. They were abundant in the ocean that covered Kansas and the Rocky Mountains, from the Arctic Ocean to the Gulf of Mexico, during the Cretaceous Age.

FLYING REPTILES

The flying reptiles (Pterosaurs) of the Mesozoic are the nearest approach among known animals to the flying dragons of mythology, pictured in so lifelike a way in many fairy tales. But none of the fossils that have been found equal these mythical ones in size or ferocity. The flying reptiles of mythology were huge lizard-like beasts with usually two wings in



Courtesy of Ginn and Company

WINGED REPTILES, WINGLESS BIRDS, BIRDS WITH TEETH

In the picture is a flying reptile, Pteranodon (upper right), with a wing-spread of 16 feet; a long-necked plesiosaur; a mosasaur catching a squid; and a wingless bird, Hesperornis, diving for fish.

REPTILES OF TO-DAY

The snake, the alligator, the crocodile, the turtle, the lizard, the striped lizard, the chameleon. Read more about them in Volume Three, pages 237-294.

addition to four legs. (The Japanese and Chinese dragons are never depicted with wings although they are shown as flying.) In the fossils of the real flying reptiles there were only four limbs, the front pair of which had become wings. The wing was stretched between the very long little finger and the hind limb. The dragons of mythology had a long heavy tail, while in the real flying reptiles the tail was very slender and in some species quite short. The animals living during the earlier Mesozoic had snake-like teeth. Later ones were toothless with horny, bird-like beaks.

One of these latter, Pteranodon, measured 16 feet from tip to tip of wing, about twice the size of the bald eagle, which measures seven feet. It was abundant in North America during the later Mesozoic times. Its broad wings and light build enabled it to fly far over the sea that at this time extended through central North America from the Arctic Ocean to the Gulf of Mexico. These ancient reptiles thus traveled many of the routes taken by the modern airplanes which they also resembled in their wing-span. The flying reptiles varied much in size. Some fully grown ones were about as large as sparrows. Very small dragons indeed! Others had a spread of wing of 25 feet.

BIRDS WITH TEETH

To-day birds do not have teeth. Hence the expression arose, "As scarce as hens' teeth," meaning none. Yet during the ancient Mesozoic time all birds had teeth. The earliest known birds looked much like a cross between a snake and a lizard dressed up with feathers. Two different species are known from the middle Mesozoic. They were about the size of a crow. These birds were really glorified reptiles. The head was snake-like in the absence of a horny beak and in narrowing gradually from the back of the skull to the tip of the mouth. In a present-day bird the head narrows suddenly at the beginning of the beak. Since this very ancient bird had claws upon the tips of its wings as well as upon the feet, it probably climbed at times among the branches of trees. Its sharp, pointed teeth indicate that it ate flesh, probably fish. Its long body and very long jointed tail are lizard-like. The wings and tail were bordered with much longer feathers than other parts of

the body. During the later Mesozoic the birds were much more like those of the present. They still, however, had much smaller brains and teeth in both jaws, though in the upper jaw they were present only in the back portion. One of these, Hesperornis, which had no wings, was a diving bird something like the loon of to-day. Another one, Ichthyornis, looked more like a modern gull. Both, with their backward projecting teeth, probably lived largely upon fish.

MAMMALS, EARTH'S RULERS FOR FIFTY MILLION YEARS BEFORE MAN

The ability to keep the inside of the body at the same high temperature night and day, winter and summer, was acquired by two classes of animals during the Mesozoic Age. These are the birds and the mammals. In mammals the body temperature is kept at 98° and in birds at 100° Fahrenheit. All other animals, whether living in the ocean, upon the land, or in the air, are cold-blooded.* That is, the temperature of the body falls if the water or air becomes cold and rises if it becomes hot. On a cold morning the snake (a cold-blooded animal) is very sluggish if it moves at all, but it becomes warm and active when the sun shines on it. When winter comes the cold-blooded land animals, such as insects, spiders, toads and reptiles, hide in the ground or in holes in trees or buildings. They do this so that, when they become so cold that they cannot move, they will be safe from animals that would eat them. Birds and mammals, being warm-blooded, are able to remain active all winter long.

Mammals are animals which instead of laying eggs produce their young alive. After birth the mother feeds them for a time on milk secreted by glands in her breast.

Mammals appeared upon earth in the Mesozoic Era; but they remained small, none longer than a small sheep, until the huge reptiles had disappeared. From the beginning of the Cenozoic to the present they have been very numerous, varying in size from the mouse to the elephant and the whale.

Mammals of the Mesozoic and early Cenozoic Eras had smaller brains than their successors, although theirs were larger than the brains of

THE HUGE GRASS-EATING ARSINOITHERIUM (See page 288)

Attacked by a pack of more agile flesh-eaters.

dinosaurs. One of the largest of these small-brained mammals, of the early Cenozoic is called Eobasileus. It had an elephant-like body and legs, but an absurd-looking head. This was long and flat with two horns at the end of its nose and four farther back. In the upper jaw were two sharp tusks projecting toward the ground.

There soon appeared, however, many mammals with much larger brains and more slender bones and with more active muscles. Being thus more cunning and quicker in action than the small-brained mammals, they gradually killed them off and ruled supreme over the lands until man appeared. These large-brained mammals include the direct ancestors of all the well-known mammals of to-day — the lion and wolf, horse and cow, deer and camel, elephant and monkey. The earliest of these groups of animals to make its appearance in the Cenozoic was in each case small. The earliest known ancestor of the

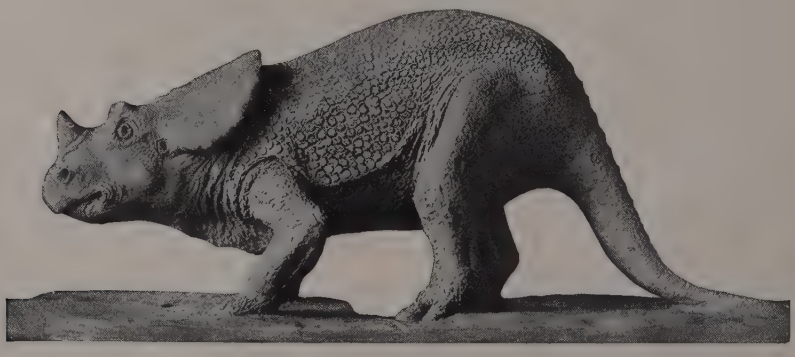
* See Volume Ten, pages 356–358.

horse was about as big as the red fox of to-day. The first camel was about the same size and the elephant was but little larger. In each case, however, some of the descendants became larger and larger as the centuries passed, until by the middle and later Cenozoic many huge animals had developed. The horse evolving in the west-central portion of North America, when the land was changing from moist to dry, had to travel farther and farther from grazing land to water holes. These larger and swifter horses would be strong and have strong offspring because they had plenty to eat and drink. Gradually the smaller and less swift horses were killed off by the flesh-eating mammals. These flesh-eaters, especially members of the cat and dog families, had also become larger and swifter during the same period. It thus came about that only the larger horses remained. As the horse became larger so did also the camel and the deer.

During the middle and later Cenozoic many large animals evolved in the different orders of the large-brained mammals. Among the hoofed mammals one of the largest during the middle Cenozoic was the flat-horned Brontothere. This was seven feet high and twelve feet long. It had an elephant-like body and legs and most conspicuous flat horns at the end of its nose. Another huge-hoofed mammal from the middle Cenozoic was the rhinoceros-like Arsinoitherium. This was about six feet high, with a pair of enormous, forwardly projecting horns over its nose and a smaller pair above the eyes.

As with all other large mammals of to-day the ancestor of the elephant way back in the early Cenozoic was a small animal. It looked much like a tapir with a short flexible nose. As the ages passed its descendants grew larger and the nose became longer, developing into the trunk. One pair of incisor teeth in the upper jaw grew very long and became the tusks. In some of the extinct elephants there was another shorter pair of tusks in the lower jaw.

Just as some of the land reptiles gradually changed to a life in the water, so too did some mammals. Among the mammals to-day the whale is best fitted to a life in the open ocean far from land. Its front legs have become paddles; it has lost its hind legs and its tail has broadened greatly and forms a fin. But since its walking and running ancestors in the early Cenozoic were air-breathers it must also breathe air; and so must come to the surface of the ocean at frequent periods. The seals and sea lions have not changed so fully to a water life, as they are still able to move about upon land. Instead of losing their hind legs and developing the tail into a broad, fish-like fin, the tail has been almost entirely lost, and the hind limbs have developed into very efficient paddles.



EARLY MAN

This story of prehistoric man is one which scientists have slowly and laboriously pieced together from scattered bits of evidence in rocks and caves and the finding of ancient skeletons and rude tools. Many people do not accept this story as true because they feel that it conflicts with religion. Many others do accept it as a reasonable picture of what may have happened in prehistoric times and do not think that it contradicts in any way the fundamental teachings of Christianity. Even the scientists who worked out the story do not claim that it must be accepted as strictly and literally true in every detail. They simply offer it as the story of what seems most possible or probable, judging from the evidence they have found.

WE see living in the world to-day White people, Negroes, and Mongolians. We never mistake one for another. Each has easily seen differences in color, hair, eyes and face. There are also other and more important differences in the bones of the body. Skeletons found in rocks of the earth 50,000 years old show that there were Whites, Negroes, and Mongolians even in those ancient days, though they were different from those living to-day. In still older rocks are found human skeletons that are entirely different from those of any of the living races. It is now known that man has been living upon earth for more than a million years.

HOW YEARS ARE RECKONED FOR THE AGES BEFORE WRITTEN HISTORY

To-day people are writing their history day by day and year by year in newspapers, magazines, and books, upon coins and stone monuments. But printing did not begin in Europe till the fifth century A.D. Coins go back only to the eighth century B.C., while the carved inscriptions that are constantly being found belong to the early days of the alphabet. Peoples whom we know thus by means of their own writings we call "historic peoples." The actions of these peoples and the story of whatever has happened to them may be tagged with years quite exactly by means of their own writings. Earlier than this, we must depend upon other means to find out dates and periods.

Man has always used tools. From the earliest times he has needed implements for getting food and for preparing it for eating. Such tools are plentiful in the muds and sands laid down by streams through many ages. Often they are found beside the skeleton of the man who had used them in those distant days. For dating these, the movements of the great glaciers and the deepening of valleys by the streams which flow in them are principally used.

The time when these glaciers covered parts of the earth geologists call the Pleistocene or Glacial Period. It occurred immediately before the present, — the Holocene Period. At different times during the Pleistocene Age glaciers covered large portions of Europe and North America as well as the mountains in the warmer parts of the world. It took 12,000 years for the last of these great glaciers to melt back from southern Sweden to the present remnants in northern Sweden. This length of time was determined by the Swedish geologist, De Geer, who counted the number of bands in a series of lakes from southern to northern Sweden. The lower part of each band was made by the thicker layer of sand washed into the lake by the large amount of water due to the summer melting of the glacier. The upper part of the band is made by the very thin deposit of clay laid down during the winter. This 12,000 years is only a small part of the time necessary to melt this last glacier back from its farthest advance in central Germany and Russia. It must also have taken the glacier as long to move southward as it did to melt away again. Geologists have studied three great advances of the glaciers and many more local advances. Reckoned with the 12,000 yard-

stick from Sweden, the advances and retreats of all these glaciers must have taken a very long time.

But besides the time necessary for all this, there were very long warm periods, warmer than to-day, between these cold glacial times. During these warm times such warmth-loving animals as the saber-toothed tiger, straight-tusked elephant and broad-nosed rhinoceros, and such warm-climate plants as the fig and sweet bay lived as far north as France and England. How long each of these warm periods lasted, is reckoned from the thickness of the muds and sands laid down by the rivers, from the animal and plant fossils found, and from the depth that rivers in other places cut down their valleys during that time.

By such methods the geologist gets a rough idea of the length of the Pleistocene Age. It is not nearly so exact as what we can get later from written records. We know, however, that the Pleistocene must have been at least a million years long, possibly a million and a quarter. The alternating warm and cold times divide this long period into shorter time divisions. The layers of mud and sand laid down by streams during each time may be recognized by the plants or bones of animals found in them. They are the plants and animals that lived during those times.

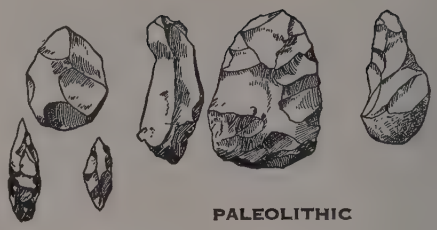
MAN IS NAMED FROM THE MATERIAL OF HIS BEST TOOLS

In the very early times of man's existence on earth the best tools were made by chipping stones into the shape desired. This time in the history of mankind is known as the Paleolithic, or the Old Stone Age.

Later, some men learned how to grind off the rough points of their chipped tools and make them into smooth implements. Men with this power are called Neolithic, or the New Stone Age people.

Still later some learned how to melt copper and tin together, forming bronze, and make from this new material sharper and less brittle implements. People who could do this are said to be in the Bronze Age.

When in a later time some men learned how to melt iron ore and from this purified rock make iron tools, they are said to be in the Iron Age of development.



PALEOLITHIC

Most countries to-day are in the Iron Age of their development. As late as 1500 A.D. more than half of the lands of the earth were in the Stone Age, mostly Neolithic, some Paleolithic. Some few were in the Bronze Age and the rest in the Iron Age.

PALEOLITHIC MAN, A HUNTER

There is no evidence that men of very early times cultivated the soil. All the implements found have to do with the killing of animals for food and the scraping of skins for clothing. These men must thus have been hunters, living upon the animals they could kill and the wild fruits and roots they could find.

LOWER PALEOLITHIC MAN

The oldest tools so far found which all students of this subject agree to have been made by man are from the lower Pleistocene and the upper part of the preceding period, the Pliocene. These early human tools are very simple and include rough spearheads and scrapers for cleaning the inside of hides. The most typical tools, called by students "hand-hammers" (*coups-de-poing*), are shaped somewhat like a pear. Such primitive implements are found in many parts of Europe, North Africa, and in Asia as far east as China. Portions of the skeletons of man (the Piltdown man) have been found with these implements in southern England. Markings on the inside of the skull indicate that this man had a slight speech center in his brain and hence could talk. More lately portions of other human skeletons were found in an ancient cave in China, near Peking. Here there appears to be no doubt that the age is early Pleistocene, for, lying with the

human bones, and covered with sand and dust blown into the cave and with pieces of rock fallen from the roof, are the bones of very early Pleistocene animals.

Belonging to this early type of man are also a lower jaw found near Heidelberg, Germany, and several parts of a skeleton found in Java. The inside of the skull of this Java man shows that the speech center was developed about half as much as in man of to-day.

For more than a million years men with such primitive weapons competed with savage animals for a chance to live. That they succeeded there can be no doubt, for man is still here.

MIDDLE PALEOLITHIC MAN

The best-known people of this age belong to the low-browed Neanderthal race. The men of this race stood about five feet high; the women were shorter. Tools and skeletons of these people have been found in Europe, Asia and Africa. Their hand-hammers were smaller and better made than those of the Lower Paleolithic people. They also had knives, scrapers for cleaning hides, and pointed stones probably for making holes in these hides to tie them together for clothing. These were all chipped on one face or side only.

The skeletons of these people have thick heavy bones with large joints. The head has a retreating forehead. The jaws are massive and the chin retreating, almost no chin at all. We know they were right-handed, for the left side of the brain (which governs the right side of the body) is slightly more developed than the right, and the upper bone of the right arm is stronger than that of the left arm. These bones and joints of the skeletons show that these people had huge muscles and walked with a stooping body. With their primitive tools their strong bodies stood them in good stead in their constant struggle with the wild animals. They are first known in Europe about 150,000 years ago, and ruled there until killed off by a more intelligent type of man some 50,000 years ago. So for 100,000 years these low-browed, heavy-limbed, huge-muscled men ruled the human world by brute strength.

But finally, as always happens, brute strength gave way before finer brains. A new type of man appeared who had a well-developed forehead indicating a high degree of intelligence, who was light-boned and straight-limbed, with muscles developed for quickness of motion rather than brute strength.

UPPER PALEOLITHIC MAN
BEGINNINGS OF THE WHITE, NEGRO, AND MONGOLIAN RACES

None of the men so far described belong to any of the modern races. They do not even belong to the modern species of man. All men living to-day belong to one and the same species, which scientists call "Homo sapiens." This, translated, means the "wise man." We see man's pride in the name he has given himself. The Middle Paleolithic men belonged to the species called "Homo neanderthalensis," that is, "man of the Neander Valley." In this valley in Germany the first skeleton belonging to this race was found and described.

The earliest known men belonging to "Homo sapiens" are found buried in caves and from muds of river valleys of that time. These were laid down during the time of the last great cold period, the time of the great glaciers of the later Pleistocene. During the many thousands of years of the later Pleistocene three races of "Homo sapiens" came into Europe, — the Grimaldi, the Cro-magnon and the Chancelade. All of these men had slender bones with small joints. The head had a high forehead and small jaws with a prominent chin. That is, they must have looked very much as we do.

Of these three races the Chancelade were so much like the present-day Eskimos that some students think the latter are direct descendants. Both races are short. They are alike in every feature of the skull. The Cro-magnon had much in common with the present white race, and some of their purer descendants are supposed to be living to-day in the Dordogne district of southwestern France and in the Canary Islands.

The Grimaldi race were the Negroes of the Glacial Period. Comparing the bone of the Negro and the White to-day, the Negro leg is longer in relation to the arm than the White; the lower leg is very long in proportion to the thigh, and the forearm to the upper arm. All this is true of the Grimaldi skeletons. Their skulls, too, were like those of the present-day Negro.

Courtesy of American Museum of Natural History

SIBERIAN MAMMOTH

Courtesy of American Museum of Natural History, New York

SKELETON OF AN ELEPHANT THAT LIVED IN NORTH AMERICA IN ANCIENT DAYS

EARTH'S RULERS DURING THE LATER PLEISTOCENE

These races conquered Europe during the later Pleistocene. They knew more and could do more than the Neanderthal race then living there. Besides making use of wood and stone in the manufacture of their tools, they also used the horn of antlers and the tusks of elephants. They had the spear, knife, harpoon, and probably also the bow and arrow for getting food; the shuttle, pin and needle for making clothes; the drill, chisel and polisher for drawing figures of animals upon stone or ivory; and wands for ceremonial affairs.

The coming of these intelligent and active races was a catastrophe for the much less intelligent and less active though big-muscled Neanderthal people. It looks as if they hunted down these low-browed people as man to-day does the tiger or the grizzly bear. They were too different, both in body and in mind, to do anything but fight when they met. In the many places where implements of the low-browed Neanderthal people and of the ancient representatives of "Homo sapiens" are found together those of the latter are immediately above. That is, the more intelligent people lived in the same region or even in the same cave after they had killed off the former inhabitants.

THE ART OF THE UPPER PALEOLITHIC PEOPLE

These earliest known representatives of the species of man to which we belong ("Homo sapiens") are also the oldest known sculptors and painters. Many of them lived in caves as the Neanderthal people did before them. Others lived in huts built of wood or skin. These are, of course, entirely rotted away; but we know they made them since there are drawings of them on the walls of caves they occupied. Thirty caves have already been found in northern Spain and southern France which have drawings and paintings made during the later Pleistocene upon their walls. Here are seen drawings or paintings of the horse, bison, deer, swan, wild goose, trout, pike, salmon, as well as such extinct animals as the hairy mammoth and the hairy rhinoceros.

When the sketches of the mammoth and the rhinoceros were found scientists thought that the ancient artists could not possibly mean that these animals had a long coat of hair. To-day the elephant and the rhinoceros have hardly any hair. Later, when some of these ancient animals, complete as in life, were found still entirely frozen in the ancient swamps of northern Siberia, it was seen that these early artists had known and hunted such in Europe.

These wall pictures are nearly all of animals which were eaten by these hunter and fisher folk. As they are usually drawn far back in the cave where it is dark, it is thought that the drawings were used as a sort of magic aid in getting food. Many savage tribes to-day believe that if they have a picture or image of an animal it gives them power over it. Some of the less intelligent persons in more civilized nations to-day will get a picture, or make an image of a person over whom they wish to hold control. So it is supposed these later Pleistocene people made pictures and sculptures of such animals as they wished to capture for food.

Besides this art for magic purposes these people had also a home art. They made sketches on stone and ivory of many different animals which lived around them and of different activities of man. From stone and antlers and ivory they also carved figures of animals and of men and women. Some of these figures are wonderfully well done and with great detail: other figures appear to have been carved by beginners in art, while still others seem to have been made for fun.

NEOLITHIC MAN, A FARMER

A warmer climate followed the melting back of the last series of great glaciers. During this warmer time, with conditions much like those of to-day, a more intelligent type of man migrated into Europe from Asia. This new type of man, "Homo sapiens," was still in the Stone Age of culture, but since he had learned how to smooth his tools instead of merely chipping them he is said to belong to the New Stone Age, or the Neolithic culture stage.

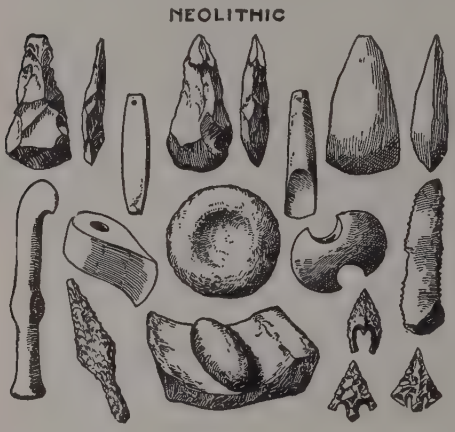
MAN LEARNS TO TILL THE SOIL

The Neolithic man was not so artistic as was man of the late Paleolithic but he had a greater

ARTIST CAVE MEN OF THE STONE AGE (Upper Paleolithic)

"Notice how the primitive artists caught the most important characteristics of the animal, emphasizing the horns of the reindeer and the hump of the bison." See page 298.

control over nature. He knew how to make the ground yield him food. He is the earliest known farmer. Instead of depending entirely upon what he could find by hunting, he cleared the ground and planted seeds. He also captured wild animals and tamed them for his use. We know he came from Asia because some of the seeds he cultivated and some of his domestic animals existed in a wild state only in Asia. He brought



with him wheat, barley and millet, shorthorn and longhorn cattle, the pig, and probably also the sheep and the goat. After entering Europe he captured and tamed the European forest horse and a plateau type of pony. His drawings show that he also had the dog. But domestic animals remained few in number until much later, during the Bronze Age.

The incoming of a farmer people means that hunters must disappear, for about one thousand farmers can subsist upon the same amount of land as can one hunter. So the Neolithic farmers gradually replaced the Paleolithic hunters. This came about because some of the Paleolithic hunters followed northward after the reindeer, which formed much of their food. Others mixed with the Neolithic farmers and gradually learned their ways. That they did this is found out in the same way that a student could tell without written records the story of the white invasion of America. In some cases there is found a mingling of Indian and other tools and implements over a long period, while Indian arrowheads, stone hammers, etc., become fewer until they finally disappear. In such cases it is plain that the Indian gradually acquired the white man's civilization. In other cases, where the tools of the Whites rest upon those of the Indians with very slight mingling at first, the Indians were doubtless killed off, or more usually they followed the wild animals which retreated before the plough of the farmer.

In regions like the Nile Valley, where the river fertilizes the ground each year by overflowing its banks, and where there are no trees to clear away, agriculture began much earlier than elsewhere. In Egypt it may have begun 20,000 years ago. In Europe it began about 7000 B.C.

Cremation was generally practiced during the Neolithic Age. These people burned the bodies of their dead and placed the charred remains in an urn to be buried in a mound, called by modern students a "barrow." Such barrows are rather common to-day from England southeast through Europe. Cremation was also common in the Bronze Age.

THE METAL AGE OF MAN. MAN LEARNS HOW TO SMELT ORES

Man was on earth for millions of years before he learned how to melt ores and then cast the molten material into tools. He could do this only after there had accumulated a large body of knowledge. Very slowly the successive generations of men through the Paleolithic and Neolithic Ages had learned new facts about nature. This body of knowledge the elders of one generation taught to the young of the next generation; so that by the end of the Neolithic Age man knew many ways of making nature help him to live a fuller life. He knew how to make sun-dried bricks out of mud for building his houses and how to shape true pottery. He could pound native gold and copper into ornaments, and drill holes through beautiful stones to make necklaces. With wood he made chests and other household furniture, boats and houses. Men living in a region of lakes, like Switzerland, often built their houses upon piles or posts set out in the water, with a platform made of movable logs leading to the shore. Neolithic man could also make the earth yield him the kind of food he wished by digging and fertilizing it, by

keeping down the weeds and killing trees to let in the sunlight. He could control fire to give him heat and light and cook his food. That is, he had learned to see the relation of cause to effect in many different ways in his everyday life. So it was natural that by this time some of the more observant men should ponder over the melting of some stones at the center of some camp fires. (It is supposed that the first knowledge of melting arose from such a chance discovery by an observant, thoughtful man.) The next two steps would be to gather the same kind of rocks and melt them on purpose, then to make a mold in a stone and let the molten material flow into it.

BRONZE AGE MEN, SMELTERS OF COPPER AND TIN

It was a great step when man first learned how to melt copper and tin together to form bronze. Bronze could be given a sharper edge than could stone and was very much less brittle. It could also be made into a greater variety of shapes. The Bronze Age began in Egypt and the eastern Mediterranean lands about 2200 B.C., in Central and Northern Europe a little later.

IRON AGE MEN, WORKERS IN IRON

The Iron Age is marked by a general adoption of iron for tools. Bronze and stone continued to be used for many purposes, just as we to-day make use of all three. The knowledge of working iron naturally began earlier in some regions than in others. It then spread from one people to another. Thus the Canaanites were in the Iron Age before the Israelites, and their iron chariots in the days of the Judges gave them an enormous advantage over the Israelites. By the time of David, however, the Israelites had learned the science of iron working. Around the Mediterranean the Iron Age began about 1000 B.C.; north of the Alps it began about 500 B.C. Such dates cannot, however, be very exact.

GEOLOGIC PERIODS	Climatic Conditions	Man	Cultural Divisions			Time Estimate
HOLOCENE	Gradual rise of depressed lands { Climate as to-day / Climate warmer than to-day } Ocean waters flooding depressed lands	Homo sapiens Modern races	Agricultural Stage	Metal Age	Iron	1,000
					Bronze	2,000
				Stone Age	Neolithic	7,000
PLEISTOCENE	Melting back of last glaciers 4th Glacial Advance 3rd Interglacial (warmer) 3rd Glacial Advance 2nd Interglacial (warm) 2nd Glacial Advance 1st Interglacial (warm) 1st Glacial	Homo sapiens; Ancient Chancelade race Cro-magnon race Grimaldi race	Hunter Stage		Paleolithic upper	50,000
		Homo neanderthalensis			Paleolithic middle	150,000
		Very early men—Piltdown, Heidelberg, Java, Pekin, etc.			Paleolithic lower	1,000,000
PLIOCENE	Warm fauna and flora					7,000,000

STONE AGE DRAWINGS ON THE WALLS OF ALTAMIRA CAVE IN SPAIN

"These early paintings, so energetic and alive, are in flat colors of red, yellow, and brown, outlined in black." See the story of "Painting," Volume Five, page 274.

THE FINDING OF THE CAVE DRAWINGS

A WONDERFUL DISCOVERY BY A CHILD

ALL through southern France and Spain the limestone formation of the country has lent itself during various periods in geologic development to the creation of vast underground caves, caverns, and grottoes. Subterranean streams wearing through the soft rock left chambers of great depth which in earlier periods were evidently easily accessible to the outer world. Investigation of the contents of such caves has been going on for many years, the usual discoveries being flints, stones, tools, burial piles, and all the other practical paraphernalia of life familiar to every student of archæology.

A Spanish nobleman by the name of Sautuola, an archæologist, was greatly impressed at the Paris International Exhibition of 1878 with the prehistoric collections of such finds made up from newly opened caves in southern France. Returning to his home he began to explore certain caves near his estate. From his exploration comes one of the most important discoveries of modern times, as well as a most charming incident in the annals of archæological research.

Sautuola's little daughter accompanied him on some of these exploring trips. One day while her father was searching on the floor of a cavern among the usual archæological débris, she wearied of the slow business and began looking about. "A bull," she cried suddenly, pointing to the roof of the cave. At first her father did not heed, but as she persisted, he lifted his lamp to look at the ceiling. There he saw the famous Altamira paintings, of a few of which we have been able to make reproductions on the opposite page, the roof of the cave being overlaid with drawings of a crowd of figures faithfully representing bulls, horses, deer, some of them lifesize, in a great variety of movements and attitudes.

THE ALTAMIRA DRAWINGS AND THE ARTISTS WHO MADE THEM

Our own reproductions are in black and white, but the originals are in soft red and yellow tints. Study of them has revealed much concerning the men who did them. Before we consider these results, let us study the drawings we have been able to reproduce. Some are quite distinct, others are overlaid one on another, probably representing long intervals of time.

Beginning at the top of the page, the first figure (A) is of a hind, a small sketch of a bison showing at the right. The drawing from which this was taken is nearly three yards long. Next (B) is a horse, quite like our own horses, painted over an earlier sketch, still very distinct, of a small hind. The bison (C and D) are two of the best preserved and most vivid and lifelike of any of the hundreds of drawings since found in France or Spain, showing not only artistic sense and skill, but a careful study of anatomy and considerable ability in perspective and the representation of action. An artist began in the next panel (E) to draw a galloping beast; he or some other artist finished with the same animal walking, but in the opposite panel (F) a complete picture of a galloping boar is undisturbed. On the bottom line (G and H) are curious effects of superposition, an ox at the left with a boar, and peering over the two a horse's head, and at the right an animal lowing.

Since this discovery similar finds have been made in other caverns in France and Spain, till there is revealed a school of art extending over a considerable area. Think for a moment of the wonder of the preservation of these sketches. Now in the nineteenth and twentieth centuries of the Christian era modern men dig away the rock formations which have obstructed for untold centuries the entrances to these wonderful caverns, and stand suddenly in the presence of handicraft of artists of real genius who lived in remote ages, men who entered these caves, probably with religious as well as artistic impulse, painted on the walls their beautiful delineations of the life about them, and passed on with their generation, never dreaming of others who so many hundred years later would suddenly come upon these tokens of their life and find in them a link of common artistry and common humanity.

Drawings like these make it plain that our prehistoric ancestors were not mere brutish creatures, intent only on keeping themselves alive, warm and fed. In the midst of their struggle for existence they had an eye for beauty and a desire to draw and paint.

EGYPTIAN CARVINGS, FOUND ON RUINS OF TEMPLE WALLS

PEOPLES OF LONG AGO

EGYPT

WHO of us has not envied Columbus the thrill of stepping on a really "new" land? Who would not like to have been an explorer for Queen Elizabeth? There is so much of romance in first discoveries that nowadays there are many of us who would gladly undertake the discomforts and dangers of Polar voyages or of long expeditions into the Amazon jungle for the reward of looking on a region never before seen by human eyes.

The world, however, is rapidly being mapped and described, and the regions of possible new discoveries are becoming disturbingly few. So it is pleasant to think that there are almost unlimited fields of exploration that we are just beginning to realize in the enchanting science of archæology. The word itself means "the story of things that are old." Its subjects of study are the activities of the very oldest people of the earth that have left behind them the products of their work, such as tools or weapons or pottery. Instead of taking our minds on journeys over the world's surface as do geographical explorations, archæology takes us back in time through the years and the centuries to the world of our early ancestors. Buried under desert sand or deep in jungles, or perhaps right under our feet in a modern city, are tools and ornaments, scraps of dishes, worn fibers of baskets, bricks from buildings, fragments that can tell us much of the life of the people who used the tools or broke the dishes or wove the baskets. The explorer may find skeletons or mummies of these ancient men and women, and writings on monuments or clay tablets.

Nowhere has archæology explored farther or with more dazzling results than in Egypt. Just a few years ago the newspapers of the world carried descriptions of the marvels of craftsmanship that the tomb of King Tut-ankh-amen revealed. It thrilled us all to read of the golden buckles, the alabaster vases, the throne covered with gold and silver and precious stones, the chariot of gilded wood. These things were made three thousand years ago (during the Eighteenth Dynasty, about 1400 B. C.) and they testify to a people far advanced in culture. Hence it is apparent that we must follow the archæologist back much farther through the centuries if we wish to get some idea of the very earliest dwellers in the Nile Valley. We must go back from Tut-ankh-amen through another two thousand years before we reach the first recorded king of all Egypt, the Pharaoh of the First Dynasty, who, as we learn from inscriptions, lived not later than 3000 B. C. That there had been a long human history even before him is seen from the fact that his people used copper freely in the making

of weapons and ornaments and that they possessed an accurate calendar based on astronomy.

Back farther yet in time we must accordingly travel with the explorers, through a series of changing peoples, each earlier one with a culture more and more primitive, before we can catch a glimpse of those who were perhaps the really first human inhabitants of Egypt.

The history of man in Egypt began, so far as known at present, about 200,000 years ago. This was in the Pleistocene Era of earth history. These people were in the Early Paleolithic stage of culture which in Europe is known as Chellean and Achenlian. They left an abundance of coarsely chipped implements along the marshy shores of the Nile when this river flowed high above its present bed. These implements had probably been lost by these hunter folk in their pursuit of game in the bordering marshes. The Nile has been under increasing control for thousands of years, so that we are apt to forget that at one time it must have flooded its valley freely during its annual overflow, and upon its retreat left behind it vast marshes. It is on the strip of land between the desert and this marshy valley that archæologists have found the implements of these early Egyptians. Flint boulders were common in the desert, from which these ancient peoples chipped their implements. A very common form was the hand ax, called by archæologists *coup-de-poing*.

Thousands of years later, after the river had cut down its bed to a lower level, are found new types of flint implements, in what were the swampy shores of that time. These implements belong to the Mousterian culture and are similar to those made by the Neanderthal man in Europe about 150,000 years ago.

Below this terrace upon which the Mousterian implements abound occur other kinds of Paleolithic flint implements of a much later date. They are contemporaneous in age with the Upper Pleistocene Cro-magnon man in Europe, of about 50,000 years ago. These implements are especially abundant upon the younger (lower) terraces about an ancient lake in the present oasis of the Faiyum. This culture lasted for many thousands of years. It then gradually passed, as is seen in still younger deposits, through a transitional period into the Neolithic.

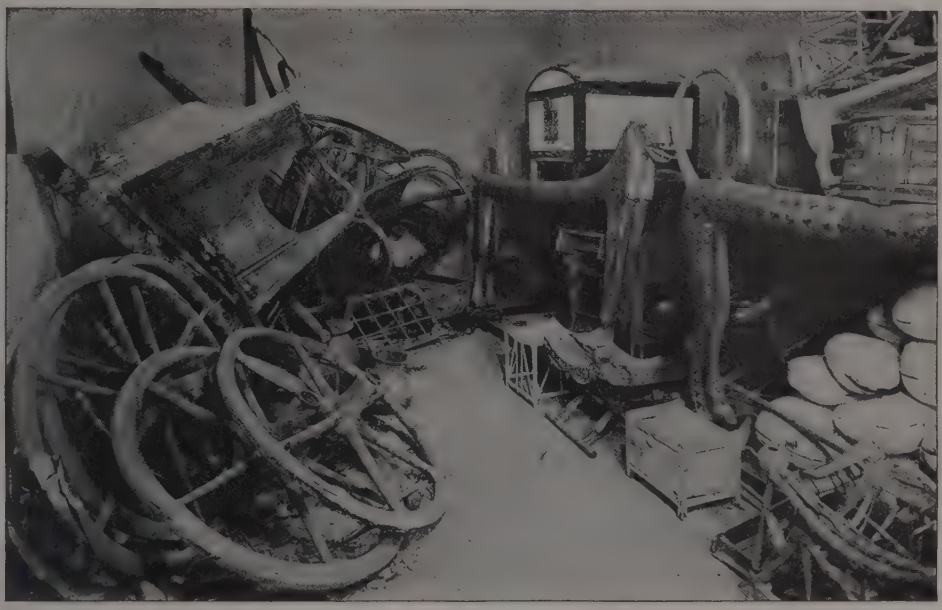
It is not known at what time man in Egypt began cultivating the soil kept rich by the annual overflow of the Nile River. It was probably quite early. At about 5000 B.C. their primitive agriculture, which may have persisted for thousands of years, was quite suddenly improved, for, about this time, men began to regulate the annual flood of the Nile by dams and canals and thus gained much broader gardens. These people used copper in addition to flint for their implements, and decorated their pottery and baskets. They had evidently passed out of the Stone Age into the Metal Age. In a few other countries, just as in Egypt, a copper culture period preceded the use of bronze.

There are many evidences that lead scholars to conclude that this change in civilization was hastened, or perhaps started, by an invasion of people from a still older and more advanced center of culture to the north, perhaps from Syria. It is these new people which seem to have brought with them the knowledge of the working of copper and of the way to make and use dams and canals. Even religion showed their influence. They brought to Egypt gods in human form. Osiris, who was from this time the chief god of the Nile people, was at first a god who presided over the growing grain. The invaders conquered and taught the older inhabitants and mixed with them. From this blended stock sprang the royal line of the First Dynasty which united all of Egypt not later than 3000 B.C. Bronze began to be used during the Fourth Dynasty and iron at about the same time.

What a story of changing life is told by the things that people make! Men must have food, so they shape weapons with which to get it and jars in which to keep or cook it from whatever materials they can find and know how to use. They must have shelter for the living and a burial place for the dead. The hunger in their souls must be fed with whatever of beauty they can achieve, and so the pottery of these first Egyptians was painted in red and black; and ivory tusks were carved into heads of long-bearded men. Their early gropings after understanding of their universe are preserved in the likenesses of their gods. Because we can come to understand something of their lives, these men and women of one of the very earliest settlements on the face of the earth link hands with us across the thousands of years that separate us.

THE TOMB OF TUT-ANKH-AMEN

Lord Carnavon (left) and Howard Carter (right) at the opening of the sealed doorway. [These photographs have been received directly from Howard Carter and are reproduced here by his permission.]



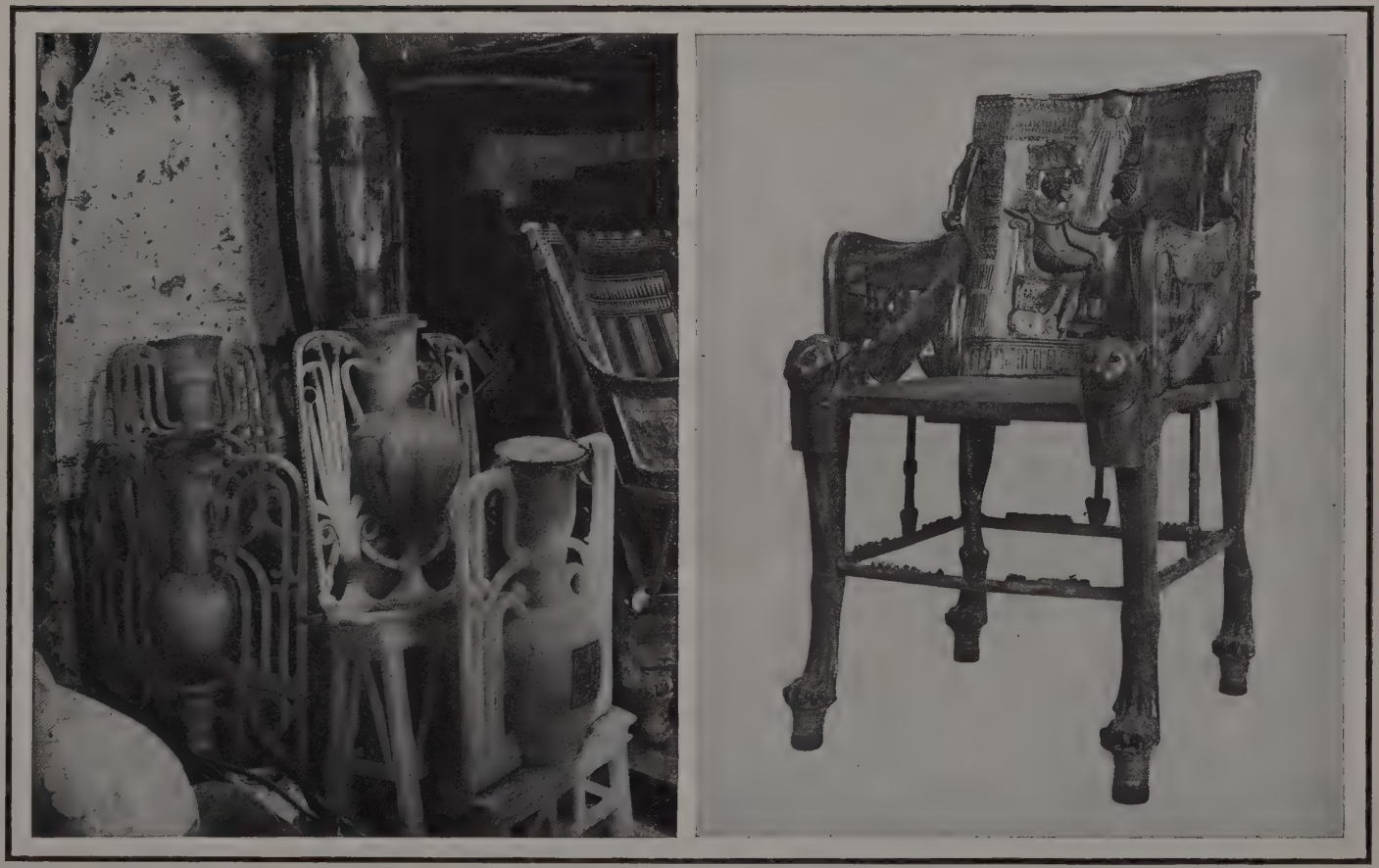
AS ONE CORNER OF THE ANTECHAMBER LOOKED WHEN OPENED

[Photograph reproduced by personal permission of Howard Carter.]

A STORY IN PICTURES

THE story told in the pictures on these three pages is of one of the most thrilling finds in the romance of archæology. On November 4, 1922, after six long seasons of unavailing work, the excavation party led by Mr. Carter was on the point of leaving the Valley of the Kings in Egypt and trying their fortune in some other spot when, as he puts it, "hardly had we set hoe to ground in our last despairing effort than we made a discovery that far exceeded our wildest dreams." The first photograph of the Valley introduces the scene of the discovery; its inset shows the leading figures in the episode: Lord Carnavon, who had financed and backed the work for years and shared season after season in its work, and Howard Carter, who made the epoch-making discovery on this November morning of a tomb which proved to be rich beyond all belief in remains of the time, long past, when its king was laid away amid the gorgeous trappings of his earthly life. In the picture of his throne chair we see how gorgeous were the possessions of this boy king of the fourteenth century B. C. in Egypt: the legs of the chair surmounted by lions' heads in chased gold, the arms of crowned and winged serpents, with tintings of violet as well as silver and gold, the back with a beautiful inlaid palace scene of the king and queen. Of the richness of their belongings we get an idea from the beautiful perfume jars set beside one of the couches. Of the labor of preserving and sorting out all these treasures, the photograph above, with its confusion of articles which had not seen the light of day for over three thousand years, gives an idea.

Further investigation led to the room where lay the mummy of the boy king, which Mr. Carter himself reburied in its tomb on October 30, 1926. It is hard to overestimate the value to science of the discovery of this treasure house of the past.



ALABASTER VASES, AND THE KING'S GOLDEN THRONE

In the antechamber stood this beautiful collection of perfume jars in carved alabaster. The throne is a chair of wood overlaid with sheet gold and richly adorned in color.
[Photographs reproduced by permission of Howard Carter.]

UR, THE CITY THAT SAW THE FLOOD

A WASTE of sand and rocks and barrenness, no green of plant, no glimpse of bird or animal, except an occasional prowling jackal, a waterless desert swept by fierce sandstorms, such is the present site of the ancient and mighty city of Ur. In all the history of past and present, is there a greater contrast?

Ur is in Iraq, near the head of the Persian Gulf, and near the ancient junction of the Tigris and Euphrates rivers. Explorations that are now being conducted have very recently revealed the fact that here under sandy mounds lie ruins of burnt brick and tablets made of clay and bearing inscriptions. The highest mound revealed the "ziggurat" of the ancient city. The ziggurat is a high pyramid, usually of sundried brick, with a shrine to the god at the summit. Another well-known ziggurat was the Tower of Babel, but that followed this one of Ur by more than a thousand years. What food is given our imagination when we try to see in our minds a city that was many hundreds of years old when the Tower of Babel was built!

Each year in the autumn the exploring expedition sent out by the British Museum and our University of Pennsylvania returns to this region and digs out more of the city from the sand that has covered it for 3000 years. We get some idea of the ease with which buildings may become buried from sight from the fact that it takes the explorers three days each year to clear their headquarters house of the sand which has drifted against it during the past few months. Sandstorms now rage across the desert for about five days out of every seven during the summer.

As more and more of the buildings are uncovered and more and more of the little clay cubes with writing upon them are found, our picture of the ancient city becomes more complete. There was a king named Mes-Anni-Padda in 3100 B.C. His people were Sumerians, forerunners of the Babylonians. They were craftsmen in gold and copper, silver and tin, and their daggers and tools were beautiful and useful. Since they made implements from copper but did not know how to combine copper and tin to form bronze they were in the Copper period, a period between the Neolithic and Bronze periods of man's cultural development.

An elaborate system of canals carried water from the Euphrates into the city. Their merchants maintained trade over large parts of Asia and Egypt. There is a record of a king who conquered the country from the Persian Gulf to the Mediterranean in 2300 B.C. and who rebuilt Ur converting it from a city of mud bricks to one of the more enduring burnt brick. Upon the ziggurat were palm gardens and a chapel to the Moon god.

Probably the most interesting discovery that the excavation at Ur has revealed was made in a cemetery and carried the history of the city back to a past that is dim in legend. The burial stones themselves are of extreme interest, for they bear dates that extend back as far as 3500 B.C. As, however, men dug still lower, down through the rubbish heap that underlay the graves, they came into a bed of clay eight feet thick, and below this again they found a layer containing painted pottery, flints and a few metal fragments, the evident products of the very primitive and earliest known inhabitants of this country. They were already in the Copper stage of development.

The real thrill of this discovery came when the meaning of the layer of clay was considered. It had obviously been laid by water; and what could have deposited an eight-foot layer of mud but a mighty flood that had overwhelmed the primitive culture of its time? Of course floods of two such great rivers as the Euphrates and the Tigris are common, but that this flood was of more than usual importance is shown by the fact that this early kind of civilization never reappeared in this place. It was replaced by that of the Sumerians, who had just learned the art of writing and whose earliest legends speak of a great flood. Hence scholars are convinced that this layer of clay under the cemetery at Ur is the enduring record of the Flood that the Hebrews heard of from the early Sumerian legends and of which they wrote in enduring prose.

Mighty was Ur of the Chaldees, one of the earliest cities in the world of which we have any record, the birthplace of Abraham and the probable site of the great Flood.

TROY, A CROSS SECTION OF HISTORY

THREE miles from the Hellespont and from the shore of the Ægean is the mound of Hissarlik. It is perhaps the most famous mound in history, for it is the site of the ancient city of Troy and overlooks the level plain on which was fought the Trojan War. Asia Minor at this point runs out to the northwest in a promontory where the range of Mount Ida sends its spurs nearly to the coast of the Sea of Marmora. Near the end of the range is this hill rising out on the plain to a height of 125 feet, on the top of which the Turks grew grain for many years.

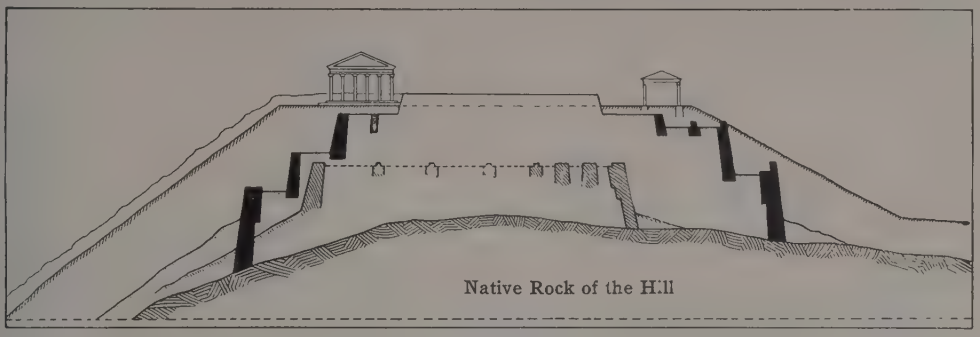
Schliemann, the enthusiastic German explorer, studied the stories of Homer from the time of his boyhood and became convinced that such a powerful city as Troy at the time of the Iliad must have left some trace to mark its former presence. His studies led him to explore this mound of Hissarlik because it seemed to fit the conditions that Homer described. He could trace the Scamander and the Simois, rivers of the Iliad; on one side was the peak of Samothrace and on the other Mount Ida. A city so situated could be easily reached from the shore, and from it a Trojan could visit the shore camp of the Greeks. So Schliemann sank a pit down into the mound. As the shaft went deeper and deeper, it proved to pass through nine successive cities, each built on the ruins of its predecessor. By 1873 he had found the remains of a very ancient city which he thought to be Troy. Later explorers now know that this ancient city was much older than Homer's Troy and that Schliemann in digging his pit had passed through the city that he was in search of; but he and the explorers that followed him have revealed to us a long series of settlements with their remains of fortifications and pieces of handicraft that give us the history of the place like a succession of tableaus.

Schliemann's original pit was fifty feet deep and at the bottom of it was the bare hilltop, seventy-five feet above the plain. On this were the very earliest traces of man. Some late Stone Age (Neolithic) people had built there a small settlement of sun-baked brick houses and walls of rough stone held together by mud. It was probably a small trading village, far back in 3000 B.C., and we can guess but little of the inhabitants from their implements of obsidian and stone and worked ivory.

On top of this was a larger city belonging to the Bronze Age. It had a massive fortress wall of rudely squared Cyclopean masonry with gates opening to the south. Pottery found here shows the first rare use of paint and the fantastic forms found in other localities and called pre-Mycenæan. There were bronze implements and primitive jewelry in gold and silver. There is evidence that this settlement was burned somewhere about 2000 B.C.

The third, fourth and fifth "cities" were evidently mere villages, each built on the remains of the preceding and each in turn destroyed, probably in most cases by fire.

The famous sixth city of Hissarlik belonged also in the Bronze period. It occupied the mound in the fourteenth or thirteenth century B.C., or rather its great fortress occupied the mound with the city spread below on the plain. The walls are of ashlar masonry, that is, of stones with squared edges like the walls of the fortifications of the city of Mycenæ, which was at that time a center of civilization on the mainland of Greece. Other evidences of the Mycenæan age of this settlement on the mound of Hissarlik are the dishes of painted ware which had evidently been imported from Mycenæ to supplement the ruder ware of home manufacture. Proved thus to be a city of the time of Mycenæ, it was without doubt the Troy that Homer told about. Much of the remains of its walls and houses was cut away when the top of the mound was leveled for the building of the eighth city; but true remains of it are still found on the southern slope of the hill, and the size of the city can be estimated. After Troy had been burned by the Greeks the mound was reoccupied by an unfortified settlement, the seventh city. This lasted until Alexander the Great rebuilt the city. Of this eighth city of Alexander, the "Hellenistic Ilium" as it is called, little trace can now be seen. There are some fortifications on the hill and on the plain. It belonged to the Iron period. The ninth city is of the Christian Era. It was a Greco-Roman city of some importance which seems to have been abandoned in the fifth century A.D. A theater and a gateway and some other buildings remain of this last occupancy of the mound of Hissarlik.



THE MOST FAMOUS MOUND IN THE WORLD

Diagram of the excavations of the hill of Hissarlik, showing three cities. Below is the rock on which the Stone Age settlement was built. The shaded walls are of the Second City; the black walls are of the Sixth City, which is the Troy of Homer; the Roman temple at the top is of the Ninth City. (Redrawn by Colby from German diagrams.)

	City	*Period*	*Century*	*Remains*
Ninth	Græco-Roman City	Christian Era	400 A. D.	Theater and gateway.
Eighth	City built by Alexander the Great	Iron Age	400-300 B. C.	Part of fortifications.
Seventh	Unfortified city			Little trace can be seen.
Sixth	Troy of Homer	Bronze Age	1400-1200 B. C.	Dishes of painted ware showing Mycenæan age of settlement; walls of stone with squared edges.
Fifth	Village Probably destroyed by fire.			Nothing remains.
Fourth	Village Probably destroyed by fire.			Nothing remains.
Third	Village Probably destroyed by fire.			Nothing remains.
Second	Larger city	Bronze Age	2000 B. C.	Pre-Mycenæan pottery showing first use of paint; bronze implements; primitive jewelry in gold and silver; fortress wall of rudely squared masonry.
First	Small trading village (Neolithic people)	Stone Age	3000 B. C.	Sun-baked brick houses; implements of obsidian, stone, and worked ivory.

PUEBLO BONITO, THE OLDEST TOWN IN NORTH AMERICA

THE New World is certainly very new in comparison with the Old. We realize this when we come from Ur to a group of ruins in the desert of northwestern New Mexico which, though the oldest known town in the United States, is yet not much over a thousand years old.

Expeditions sent out by the National Geographic Society have removed a hundred thousand tons of earth and sand from this prehistoric village. They find a mighty building of 800 rooms, an ancient apartment house that covered ten times the ground of the White House at Washington and was four stories high. There are many such ruined cliff dwellings in our Southwest, but Pueblo Bonito was the home of the oldest and largest of these great Indian communities that flourished before the time of William the Conqueror.

These people left no written record. We may build in our minds what is probably a very true picture of these early Americans from the things they left behind in these rooms and from the habits of the Pueblo Indians that are living in similar houses at the present time in other parts of New Mexico. They built their walls of stones and roofed them with beams of pine or cottonwood which served again as floors for the rooms above. They must have had a true community life, each working not only for himself and his family but for the support and protection of the whole village. There were trees to be cut down and shaped with stone axes, gardens to be planted with maize and squash and beans, clay dishes to be molded, and baskets and sandals to be woven from the strong fibers of the yucca plant. Skins were tanned for clothing and corn was ground into meal for the simple sort of bread that they baked. The finger prints of tiny hands still showing on the hardened surface of some of the bowls are evidence of the help that the children gave. The children made pets of young coyotes, eagles and hawks; and often did they make a doll by wrapping a cottonwood stick in yucca leaves and cedar bark.

Through the centuries two great anxieties have constantly clouded the lives of the pueblo-building Indian communities: the undependability of the water supply and the frequent raids by wandering Indians of the desert to the north. The garden makers of the valleys of the Nile and the Euphrates could cut canals that led the river water to their growing things. They could depend on the river that was always there, even though much shrunken at times. The garden makers of the desert of southwestern United States must depend on the occasional wild overflows when fierce and sudden rains flood the country and fill the dry river channels. They must have ready mud dikes to hold back this overflow in artificial ponds from which it may be conducted over the gardens.

It may have been a drought that was longer than usual that led to the abandonment of Pueblo Bonito. Perhaps a summer that was dryer than usual brought death to the growing things; perhaps a raid of hungry savages from the north destroyed the gardens and those who tended them and carried away the women and children. Perhaps a disease swept suddenly through the village and the few survivors migrated to other villages. For hundreds of years this house of eight hundred rooms has been alone in the desert, its walls slowly giving way under the attack of wind and the infrequent but savage rains, its rooms filling with wind-blown sand. It is known that various portions of the village were built at different times, as early as 919 A. D., for example, and in early years of the twelfth century. We know, likewise, that it was still occupied in 1127, but its later history we do not know.

The story of the determining of these definite dates is perhaps the most romantic part of the whole history of the study of the cliff dwellers. The dates are all discovered in diaries — not those in writing on clay or bark or paper, but the diaries kept by living trees. As one can see on any cut section of a tree, the trunk has grown through the years by the addition of rings. A new circle of living cells grows each year around the tree just under the bark, which grows in its turn to accommodate it. These new cells are of course added during the early summer, when it is warm and the tree can get the water and food it needs for building material. Obviously, then, the age of a tree can be told by counting its number of rings. Obviously, also, favorable summers for growth can be compared with the unfavorable by comparing the width of the rings. In this way a tree keeps a record of the years it has lived.[1] The pines from which the Indians of this region got most of their building materials are distinguished by especially clear rings. One may now cut down a tree and by counting back the rings may determine the dates of the droughts of the past two hundred years if the tree is that old. No tree living in this region at present, however, could have been living at the time that Pueblo Bonito was being occupied. Fortunately it occurred to the explorers that the beams that serve as ceiling and floor supports in the ruins were made of the pine trees which had been growing in those far-away years and that their rings would furnish a chart of the weather for the years before they had been cut. In this search, no ceiling was destroyed. Sections were cut from the part of the logs that extended out in front of the building; in other cases little plugs of the log were taken out by boring.

It then remained to link together the calendar of the past thus furnished with the calendar that modern trees have made. In order to link the youngest trees used in this ancient village with the oldest trees growing in this region today it was necessary to section trees from many other dwellings. In each case there must be a sufficient number of drought rings to link up with another tree. Finally after long search the links were complete and a record of growth rings from the beginning of Pueblo Bonito to the present was made. In this painstaking way a weather chart of southwestern New Mexico for twelve hundred years has been constructed and any ruin in that area can now be dated by sectioning one of the trunks used in its building and finding where its drought rings fit into the series.

Pueblo Bonito, though long abandoned, seems to send a greeting to us across the years when we can read in one of its roof beams that a thousand years ago a man went out with his stone ax and cut down a tree for his new home, a tree that has preserved to our time the record of its two hundred and nineteen years of growth through summer and winter, through years of plenty and years of drought.

[1] See Volume Ten, pages 242–246.

THE MAYAS

CITIES BURIED IN THE JUNGLE

DURING the first five centuries of the Christian Era there was a mighty empire in Central America. This was the Old Empire of the Mayan peoples. This early civilization of the Mayas shone like a solitary light in the blackness of the two Americas. Here, dependent primarily upon maize and beans for food and upon cotton for clothing, they developed a high degree of culture for the time in which they lived.

The country of the Mayas covered an area that had Guatemala as its first center and Yucatan as its second center. The jungle buried the ruins of the cities, and it is only in recent years that explorations have brought many of them to light. As we study them, our wonder grows at the things these early Americans did.

The Mayas had no iron or bronze. Their tools were made by polishing flint or other stones. They were in the Neolithic stage of culture. The later Mayas, those of the second empire, used some gold and copper for ornaments. Since these people did not have any domestic animals to aid them, all work had to be done by man power. Everything, including food and stones for building and roads, had to be carried or pulled by man. Their messenger service must have been by foot, by runners. The most famous road to-day of the many built by the ancient Mayas is sixty-nine miles long running due east and west from the early city of Coba to Yoxuna. Since the road does not extend to Chichen Itza, which is only seven miles to the northeast of Yoxuna, it was probably built before the founding of this city, that is, probably upwards of 2000 years ago. This raised stone road with the many temples bordering it has long since been broken by the heavy jungle growth and the climatic conditions.

While the farmer carried on the struggle with nature to obtain the great amount of food necessary to support the millions of people, and the workmen under the direction of the master builders erected pyramids and temples and built roads, the priests and nobles had time and energy to develop their reasoning and artistic abilities. They developed a system of writing, invented a calendar of wonderful accuracy, and carried the carving of stone to a high degree of artistic achievement.

THE MAYAN WRITINGS

The Mayan writings are conventionalized pictures and symbols. Each character represents an idea, as does our sign ($) for a dollar, and our figures, 1, 2, 3, etc. They had no alphabet. The oldest date recorded on their monuments corresponds to our 96 B.C. The symbols used show that there must have been a long previous development through a pure picture stage.

THE CALENDAR OF THE MAYAS

The calendar of the Mayas is remarkable for its wonderful accuracy and for the early date of its invention. All systems of calendars must be based on an exact knowledge of the length of the year. This is difficult without precise astronomical instruments. A year cannot be divided into an exact number of days or months, for it consists of 365.24 days, and 12.3 lunar months of 29.53 days each. Yet with a year so difficult to divide, the Mayas had invented a calendar almost as perfect as is our present one. They did this almost 2000 years before modern civilization first began to adopt its present calendar in 1582.

ORIGIN OF MAYAN CULTURE

It is supposed that just as the food of the Mayas originated in America, so did their culture. No relation has been traced between it and any culture of the Old World. The people themselves differ in physical type and in language from those of other continents. Only one element common in Mayan decoration is believed by some students to have come from the Old World. This is the elephant. It may have come from India by way of the South Pacific Islands, but the artists may have pictured elephants from legends handed down by the American ancestors of the Mayas themselves. The elephant is known to have been hunted by man in both North and South America before its extinction here.

Flint spearheads have been found with elephant skeletons in the position of natural burial. In these cases the elephant probably escaped after he had been wounded, carrying the flint until his death.

TEMPLES IN YUCATAN

Among the dense jungles of Yucatan have been found ruins of "Chichen Itza," "The Sacred City of the Serpents," built by races which lived on the North and South American continents in a time back of history. In the center of the city is the temple and castle, built on a pyramid of nine terraces, each faced with inlaid stone work. The body of a great stone serpent forms each of the four corners. Whoever these people were, they were master builders.

PRE-MAYAN HISTORY: DEVELOPING A FOOD SUPPLY

For the beginning of the Mayan civilization we must imagine a time in remote centuries before the Christian Era. Some savage people on the highlands of Mexico, possibly as early as 4000 B.C., first began the domestication of the wild Mexican grass, teosinte, and from it developed the maize. The growing of maize meant the beginning of Agriculture. Agriculture in turn led to settled life in villages and to increasing leisure for the development of civilization. Pottery follows agriculture and leads through the making of useful dishes to the study of making them beautiful. Little by little the early highland farmers domesticated other wild plants and thus added to their gardens beans, squash, tomatoes, peppers and tobacco.

Later, probably about 1000 B.C., the people in the wet lowlands domesticated other plants, found wild there, and added these to the plants they had brought from the highlands. These new plants included the pineapple, cocoa, cotton, and sweet potato. (The white potato appears to have been domesticated by the Incas in the highlands of Peru.) The cotton was woven into cloth upon primitive looms. They learned also how to keep bees and had domesticated turkeys and geese. They probably increased their food supply by hunting, trapping and fishing.

Up to the Christian Era the early history of the Mayas is still to a considerable extent a matter of guesswork. We must surmise many centuries of slow development to lay the foundations for the state of civilization and the achievements of which we find record in the centuries that followed. The first date recorded in the Mayan chronicles corresponds with our date of 96 B.C. The history from this time to about 1500 A.D. is divided into an Old Empire and a New Empire. It is to the peoples of these two empires that the name Mayan belongs.

THE OLD EMPIRE

The Old Empire lasted up to 600 A.D. During it dozens of cities and hundreds of villages were built, the oldest city being Tikal in Guatemala. This has the tallest building in the Maya region, 175 feet high, including the pyramid on which it was built. Copan was the most important city of the Old Empire. Its marvelous stairway has been called the most extraordinary piece of sculpture in ancient America. It was made up of ninety steps twenty-five feet wide, with the risers completely covered with carved hieroglyphs. This was built in 500 A.D. Like most of the cities of the Old Empire, Copan consisted largely of a group of main buildings on great mounds of earth which gave them an appearance of forming an acropolis. All buildings were decorated with tablets and figures.

Palenque was a city of southern Mexico at this time. Stone for carving was lacking in the region, and consequently the decorations of the buildings are in stucco relief. The most prominent structure is a tower of four stories connected by stairs inside.

The Old Empire was at its height about 520 A.D. Up to the present, the ruins of seventeen cities belonging to this empire have been found in the foothills of northern Guatemala and the surrounding area. The largest city was Quirigua. Here is the most beautiful sculpture of the Mayas which has as yet been found.

THE NEW EMPIRE

In 600 A.D. the great cities of Guatemala were for some unknown reason abandoned. There is no later date recorded in the Old Empire. One wonders what was the reason,—the invasion of some wandering enemy, a disease such as yellow fever, earthquakes, impoverishment of the soil due to too intensive cultivation — there have been many guesses. There followed three and a half centuries of transition during which the center of civilization moved north from Guatemala to the tip of Yucatan where the Renaissance of Mayan culture took place (980–1450).

Yucatan was discovered in the fifth century A.D. by scouts from the Old Empire sent out to look for new land. Chichen Itza was founded here by 530. It was a land of limestone, with no surface water, only subterranean water, and this accessible in but few places, — natural wells (cenotes) where the limestone crust had fallen down. Chichen Itza has two such cenotes, half a mile apart.

The glory of the New Empire lay in architecture rather than in sculpture. There were dozens

OLD POTTERY, MADE BY THE AMERICAN INDIANS

1 and 2 (center): from Mexico; 3 (large vase): from Argentina; the rest from Peru. One-quarter of natural size.

of cities, the three leading ones being Mayapan, Uxmal and Chichen Itza. It is recorded that in the year 1000 A.D. these three formed a confederation and for the next two centuries there was peace and prosperity and the fine arts flourished. Civil war broke out between the three cities in 1190 and Mayapan called to her aid hired soldiers from the Valley of Mexico to the northwest. These newcomers were the Toltecs, the predecessors of the Aztecs, and had a high civilization of their own. Through the control which they gradually acquired there followed the Toltec régime in Yucatan from 1200 to 1450. The two civilizations can be distinguished in the ruins they have left: the Toltec buildings, for example, are lighter in build and use columns as supports. In 1450 the Mayas in Mayapan rebelled against the Toltecs. In the ensuing warfare Mayapan was entirely destroyed and Mayan civilization came to an end. Chichen Itza and the other large cities were abandoned.

There followed civil war, famine, pestilence introduced by the earliest Spanish explorers, and conquest by the Spanish with muskets.

To-day there are 300,000 Maya Indians in Yucatan and Guatemala, working in the great fields of sisal which is raised for the manufacture of hempen twine, or gathering chicle for chewing gum. They are industrious and intelligent, but with slight memory of the vanished glories of their ancestors. The extinction of the leisured class, priests and nobles, has been followed by the loss of the accumulated wisdom and craftsmanship of the forgotten cities of the empire.

THE SERPENT MOUND IN OHIO

THE MOUND BUILDERS

LONG before the time of the Indians an earlier race of Americans lived in the Mississippi Valley. We call them mound builders, because they have left some remains in the shape of great mounds of earth. These mounds must be very ancient, for the skeletons dug out of them often fly into dust as soon as exposed to the air, a rare occurrence with the oldest bones found in Europe. They are certainly very mysterious. Some were evidently built for military defense, others for burial places, others for religious uses. Many are in the shape of birds, fishes, quadrupeds, and men. In Adams County, Ohio, is a mound in the form of a gracefully curved serpent, one thousand feet long, with jaws agape as if to swallow an egg-shaped figure in front.

The mound builders made elegant pottery, worked bone and all sorts of stones, and even forged copper. Copper they mined in large quantities and carried down the Mississippi hundreds of miles from its source on Lake Superior. But they mysteriously disappeared from their northern homes, leaving their mounds behind them. Whether they were driven away by some terrible epidemic of disease or by some overpowering human foe we shall never know. It is believed, however, that they moved to the southwest and founded under better auspices a far higher civilization. They belong to the same family, so scientists tell us, as those wonderful ancient peoples of Mexico and Central America, the Aztecs, whose wealth and culture so astonished Cortez and the Spanish conquerors of Mexico.

MODERN CAVE DWELLERS IN NORTH AFRICA

IT is a most interesting fact that there are tribes living in Africa to-day in the same kind of earth holes and underground caves that were among the first dwelling places of man. Airmen in some of their flights noticed the strange-looking spot, and photographed the scene from above, before descending to get nearer views of one of the most singular colonies in existence. The name "Troglodytes" was formerly applied to certain ancient cave-dwelling tribes in Mauretania, North Africa, the Arabian coast of the Red Sea, and the coasts of Egypt and Ethiopia, but it is now commonly used for all cave dwellers. The towns of the Troglodytes in the southern Tunisian desert, which has been opened to explorers since the French occupation, are among the chief curiosities of the sea of sand that stretches from the northern coast of Africa to the Soudan. No sign of the subterranean houses, says the artist correspondent of the "Illustrated London News," is visible from the outer world save the holes by which they are entered. Two days' journey south from the Gulf of Gabes, in the Sahara desert, is a chain of mountains called Matmata, inhabited by thousands of Berbers, men as independent as the Swiss mountaineers. In this region it was that a visitor in search of the cave dwellings came to a hole about forty feet in diameter, which was the entrance to a three-story-deep building, in which were living men, women, and children. The walls were perpendicular and were sometimes supported by rough stones. In the walls were irregular holes, some of them closed by rough doors. The vaulted ceiling of the best house of the colony was adorned with stucco, and

A TOWN OF DWELLERS UNDERGROUND PHOTOGRAPHED BY MEN OF THE AIR: TROGLODYTES' HOUSES

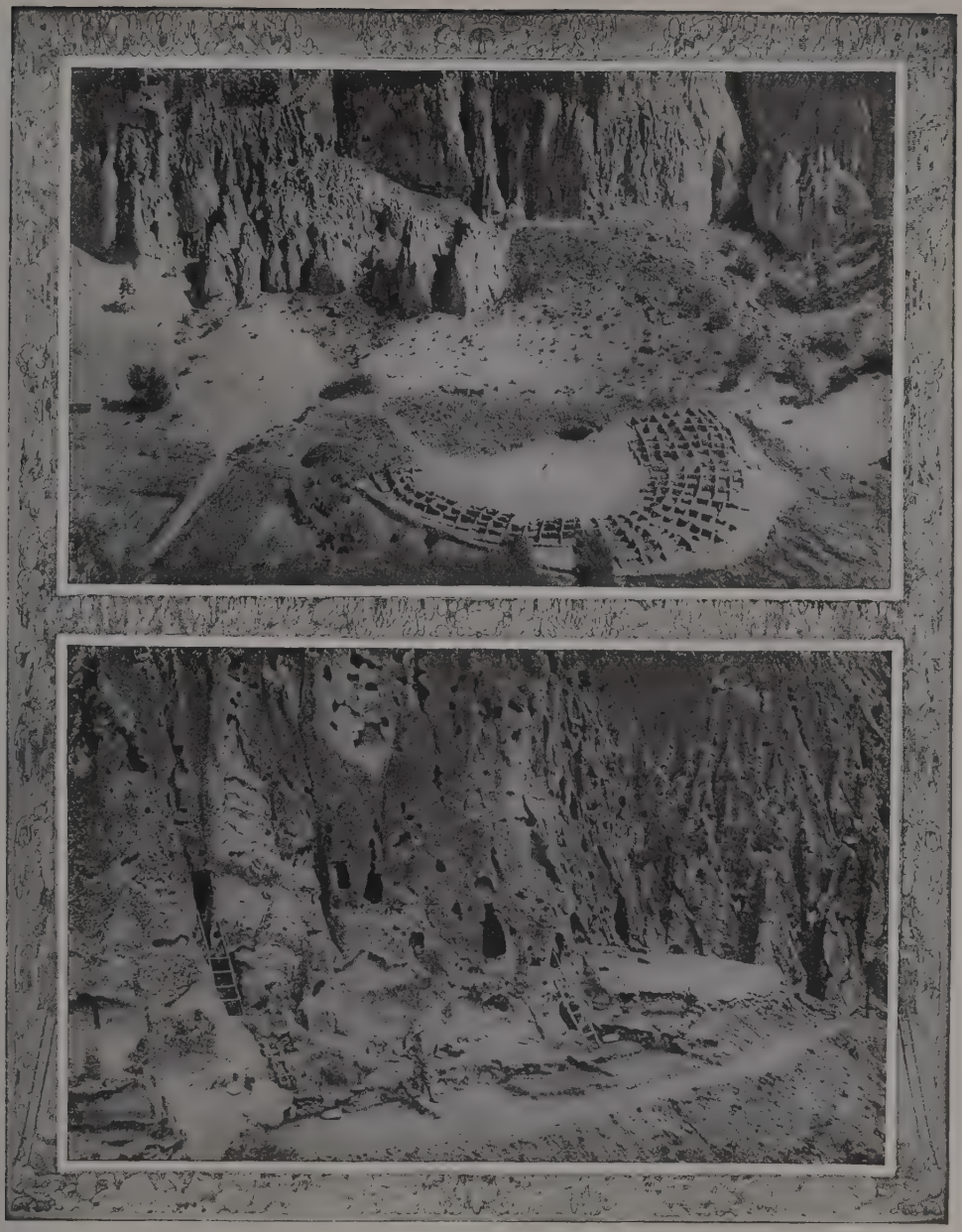
As seen from the Italian dirigible balloon "P2"; a photograph taken in Tripoli, North Africa. No sign of these cave dwellings is visible from the outer world save the holes by which they are entered. Some of the underground houses are three stories deep, and are very well built.

THE GEOGRAPHICAL DISTRIBUTION OF THE RACES IN EUROPE, ASIA, AND AFRICA

one large room had carpets hanging before the walls, a table in the center, and benches. This was the reception room and council chamber of the Kaid, an old, whitebearded man of patriarchal appearance and ancient family. In Tripoli there are large Troglodyte villages, with thousands of inhabitants, who are all Jews, and have their subterranean synagogues, their rabbis, and their Talmud schools. The cave-dwelling Berbers seem quite content with their lot and with their cave homes, which are warm in winter and cool in summer. These people are believed to be descendants of the Tamahu of the Egyptian monuments; and in their cave dwellings they represent the very earliest of man's abodes. The age of these underground dwellings it is impossible to guess, but they give every evidence of great antiquity.

AFRICAN PEOPLES

1–2, Mpongwe (Gabun); 3, Arabs (Morocco); 4, Arabs (Tunis); 5, Fellah; 6–7, Copts; 8, Nigerian; 9, Fan; 10, Berber; 11, Negro; 12, Nubian; 13, Congoese; 14, Zulu; 15, Bagirmi boy; 16–18, Africans; 19–20, Abyssinian; 21–22, Hottentots; 23, Betschuan maiden; 24, Akka; 25–26, Bushmen; 27, Madagascan; 28, Zanzibar negro; 20–30, Somali



CLIFF DWELLINGS OF NEW MEXICO

In the cañon of Rito de los Frijoles, New Mexico, there have been found wonderful ruins of a forgotten race, that built extensive villages with great communal houses and ceremonial places. Some of the houses had over a thousand rooms each and were built with great solidity. In the upper picture are shown the entrance to an underground council chamber, and the ruins of a large communal house. Below are the cave dwellings of a great "Sun-house," dug out of the steep sides of the cañon and practically inaccessible to the enemy. Of the prehistoric people who built and dwelt in these homes no other trace remains.

EASTERN OCEANIC TYPES

Top Row: Workii Tribe Man; Woman of Tonga Islands; King of Tonga Islands; Fiji Woman; Tattooed Maori Chief.
Center: A Man of Fiji, with necklace of cachalot teeth: a fine type.
Left Side: Maori Girl; Negrito Man; Burmese Girl. Right Side: Admiralty Island Woman; Tasmanian; Moro Indian Girl.
Bottom Row: Kanowit Chief; Three Samoan Belles; Samoan Man.

THE RACES AS THEY ARE TO-DAY

CAUCASIC OR WHITE DIVISION

Present Domain: North Africa, most of Europe, parts of Southwest and Central Asia, South Africa, parts of Siberia, Irania, India, Indo-China, and Malaysia, Polynesia, Australia, New Zealand, North and South America.

Population: Europe, 355,000,000; Asia, 300,000,000 (estimated); America, 115,000,000; Africa, 20,000,000; Australasia, 10,000,000. Total, 800,000,000 (?).

Physical Characters: Three types (1) Northern or Teutonic; color white or florid; height above average (5 ft. 8 in. to 6 ft.). (2) Central or Alpine; color pale white; height medium (5 ft. 5 in.). (3) Southern or Mediterranean; color pale olive or swarthy; height generally undersized (5 ft. 4 in. to 5 ft. 6 in.).

Religion: Originally nature worship; now various forms of Christianity in Europe and the Colonies; Hinduism in India; Islam in Central Asia, Siberia, Turkey, Arabia, North Africa, Irania, India, Malaysia.

Chief Subdivisions: Hamites, Semites, Aryans (including most Europeans), Polynesians.

MONGOLIC OR YELLOW DIVISION

Present Domain: Tibet, Central Asia, Mongolia, Siberia, Manchuria, Korea, Japan, Formosa, China, Indo-China; parts of Irania, Armenia, and Caucasia; most of Asia Minor; parts of Russia, Finland, Lapland, the Balkan Peninsula, and Hungary; most of Malaysia, the Philippines, and Madagascar.

Population: China, 400,000,000; Japan and Korea, 58,000,000; Mongolia, Manchuria and Siberia, 25,000,000; Central and West Asia and East Europe, 20,000,000; Malaysia and the Philippines, 48,000,000; Tibet and Indo-China, 45,000,000. Total, 596,000,000.

Physical Characters: Color yellowish and light brown; height rather under average (5 ft. 6 in.), but tall (5 ft. 8 in. or 5 ft. 10 in.) in North China and Manchuria.

Religion: Animism, worship of ancestors, nature spirits. Religions largely a question of race, Manchus, Koreans, Japanese, Chinese, Indo-China, and Tibetans being nominal Buddhists; the Turks, Tartars, and most Malays, Mohammedans; the Finns, Lapps, and Magyars now Christians. Also Confucianism and Taoism in China, Shintoism and Bushidoism in Japan.

Chief Subdivisions: Manchus, Koreans, Japanese, Turks, Finns, Lapps, Magyars, Tibetans, Burmese, Siamese, Chinese, Japanese, Dyaks, etc.

AMERIND OR RED DIVISION

Present Domain: Arctic seaboard, Greenland, Alaska, Canada, and the United States; most of Mexico, Central and South America.

Population: Full-blood Amerinds, about 10,000,000; Mestizos or half-breeds, 30,000,000 (?). Total, 40,000,000 (?).

Physical Characters: Color normally reddish or coppery, but variable, some very dark brown, some yellowish (Amazonians). Height generally well above average (5 ft. 8 in. to 6 ft. and even 6 ft. 4 in.) (Bororos, Patagonians); but some very undersized (5 ft. to 5 ft. 4 in.); as a rule prairie Indians tall, highlanders short.

Religion: Shamanism — worship of good and evil spirits; animal worship; sun worship.

Chief Subdivisions: (1) Northern: Eskimo and American Indian tribes — Apache, Navajo, Cree, Mohican, Delaware, Shawnee, Cheyenne, Huron, Mohawk, Cherokee, Seminole, Choctaw, Creek, Pawnee, Pueblo, etc. (2) Central: Aztec, Zapotec, Chiriqui, etc. (3) Southern: Incas, Carib, etc.

NEGRO OR BLACK DIVISION

1. *Eastern (Oceanic) Section*

Present Domain: Malay Peninsula, Andamans, parts of Eastern Archipelago and Philippines, New Guinea, Melanesia, Australia.

Population: 2,000,000 (?), chiefly in New Guinea and Melanesia.

Physical Characters: Color very dark brown or blackish; height generally below average of 5 ft. 6 in.

Religion: Spirit worship, with tabu in Melanesia and totemism in Australia.

2. *Western (African) Section*

Present Domain: Madagascar, North Africa, Southern United States, West Indies, Latin America.

Population (pure and mixed): Africa, 180,000,000; Madagascar, 3,000,000; America, 25,000,000. Total, 208,000,000.

Physical Characters: Color very dark brown or blackish; height above average (5 ft. 8 in. to 6 ft.); but Negritoes generally 4 ft. or under.

Religion: Animistic, ancestor worship much more prevalent than nature worship.

Chief Subdivisions: Soudanese (Negroes proper) between the Atlantic and Abyssinia and in the Welle Basin; Bantus (mixed negroid peoples) occupying nearly the whole of Africa south of the Soudan; Bushmen and Hottentots, Southwest Africa; Negritoes, Congo and Ogoway forests; Vaalpens, Transvaal.

INTERESTING PEOPLES

OF THE BLACK, BROWN, RED, YELLOW, AND WHITE RACES

IN the great human family there are many peoples whose ways and habits are unlike ours. Some are uncivilized, and so take us back to a kind of life more like that of our ancestors than anything we are acquainted with; others are highly civilized, but their civilization is of another kind from ours. It is impossible to tell about all the interesting peoples, but a few will show how fascinating is the story of other nations. All your life, as you travel and read and meet men and women, you will be adding to your knowledge of the many members of the great human family.

First, let us take some of the black peoples. The true black people are the Negroes, whose home is in the middle part of Africa. They are the people with the black skins, the woolly heads, the thick lips, the flat noses, and the beautiful white teeth. The home of the Bantu race is the great southern section of Africa. They are not so black as the Negroes. Smaller tribes are the Pygmies, the Hottentots, and the Bushmen.

AMERICAN INDIANS

1, Aleutian: 2, Kolosche; 3–4, Eskimo; 5, Vancouver; 6, Crow; 7, Blackfoot; 8, Ojibwa; 9–10, Piute; 11, Shoshone; 12, Dakota; 13, Pawnee; 14, Mandan; 15, Apache; 16, Pueblo; 17, Mexican; 18, Orinoco; 19, West Brazilian; 20–33, South American.

THE WILD BUSHMEN

HUNTERS

THE Bushmen are the true aboriginal people of South Africa, the earliest known inhabitants, as the Indians are the aboriginals of our own country. When we come to them, we have gone back many stages in the world's development, back to the days of the childhood of man, for here we have a race that has always been a hunting race. Almost every people has passed through a hunting stage in its development. The Bushmen stayed at that stage. They represent the typical hunters of the world. Free of all property, never settled in one place, never held by any industries or agricultural ties, they range the hunting grounds of Africa. Their arrows are tipped with wood, bone, or stone. They need no home, for they can make one in a few hours out of brushwood. Their usual garb is a robe of sheepskin thrown over the body and fastened with a sharp thong. The Bushman needs no fireplace or cooking utensils, for his only way of preparing food is to throw the raw flesh on the fire or on hot stones for roasting.

HOW THEY LOOK

The most conspicuous feature of the race is their shortness of stature, the average height being about four feet nine inches. The color of the skin is much lighter than the Negroes, and the hair, instead of being evenly distributed over the top and back of the head, grows in small separate tufts, like little islands with stretches of bare scalp between. Their eyes are very small and deeply sunken in the head. Their sight is wonderful. They can see without a telescope about as well as the ordinary person can see with one.

HOW THEY HUNT

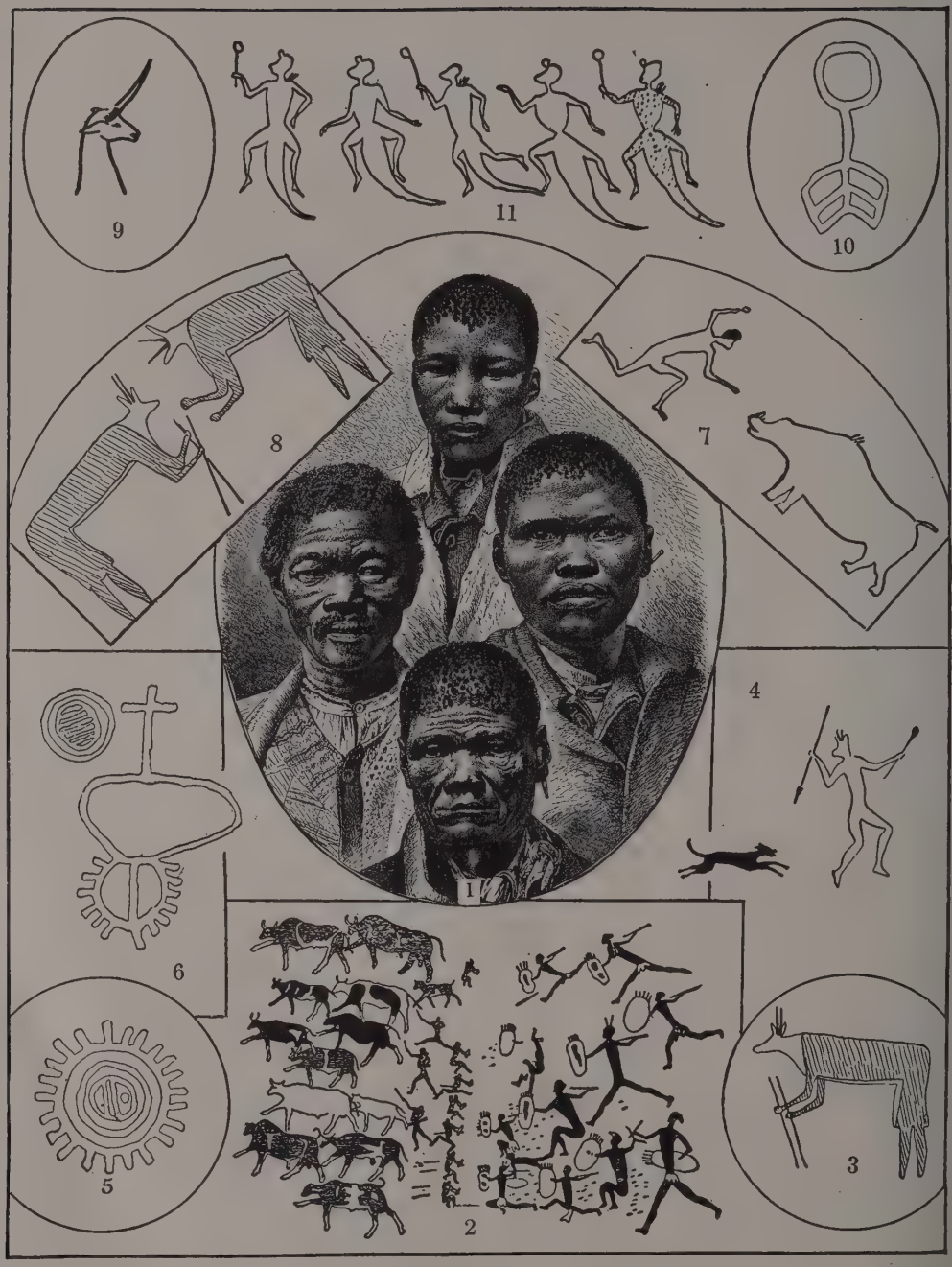
For food the Bushmen eat every creeping, running, and flying thing they can lay their hands on, including snakes and slugs. They are bold and skillful hunters of the ostrich, the lion, and the leopard, and their only weapon is a poisoned arrow. In hunting the ostrich they show great ingenuity. They have no horses, and to pursue this bird on foot would be hopeless. Accordingly the Bushmen have two modes of getting within range, which in the flat, treeless country frequented by the ostrich is no easy matter. In the first place the little hunter finds the large ostrich nest while the parent birds are away. He knows that several ostriches will deposit their eggs in one nest, so that a number of them will come back together. He approaches very cautiously and buries himself in the sand among the eggs. Here he will lie patiently until the sun has gone down, when he knows the parent birds will return to the nest. As soon as they come within range he picks out the bird that has the plumpest form, and with a single arrow seals its fate.

The chief drawback to this mode of hunting is that the very act of shooting the arrow reveals the hunter and frightens the other birds away, so that there is no chance for a second shot. So he tries another method. When he catches a glimpse of a number of ostriches together, he dresses himself up in the skin of an ostrich, so as to make the birds think that it is only another of their number feeding near them. Approaching in this manner, he is sometimes able to secure several of them before they get out of his range.

HOW THEY DEFEND THEMSELVES

The Bushman obtains the poison for his arrows from a native caterpillar. And had he not this protection, he would soon be exterminated by his cruel enemies, who are only kept at arm's length by the knowledge of the deadly effect of this little weapon.

A single Bushman lurking in the neighborhood will keep a whole settlement in terror. Sentries are almost useless when he chooses to make his night attack, for he can crawl unseen within a few yards of the sentinel, lodge a poisoned arrow in his body, and vanish as silently as he came. As to finding the retreat in which he hides himself by day, it is almost impossible, even for a Hottentot, for the Bushman is marvelously skillful in covering up tracks, and has besides the art of packing his tiny body into so small a compass that he can lie at his ease in a



BUSHMEN AND THEIR DRAWINGS

1. Four typical Bushmen. 2. The Bushmen have stolen some cattle from the Kaffirs and are driving them off, the Kaffirs in pursuit. 3, 8, 9. Animal figures, drawn on walls of caves. 4, 7. Hunting scenes. 5, 6, 10, 11. Charms, and a festival dance.

hole which seems hardly large enough to accommodate a large rabbit.

BUSHMEN AS STORY TELLERS

In the stories of the Bushmen we get beast fables and nature myths in their original form. As a group of men, women, and children sit about a fire, one will begin to tell a quaint old story. When the different animals who are the characters in the tale make conversation with each other, the story teller will imitate the sounds which each has made until the language sounds to one who is listening like a mixture of half-animal, half-human talk. These stories tell how the sun and the moon happened to be tossed up to heaven. The moon is red and cold because it was an old shoe that the monkey threw there to get it out of the way. The shoe was dusty, so the moon cannot shine as brightly as the sun; the leather was cold and dead, so the moon is.

THE BUSHMEN AS ARTISTS

But it is in Bushmen drawings that we get the best ability of these primitive peoples. They show not only clever ideas, but real skill in working them out. Every picture has a story which it is easy to trace. They are drawn in the caves or rock shelters which are the only permanent homes of the tribes. The subjects are mainly men and animals, and are drawn so accurately that the different kinds of animals, the elephant, rhinoceros, baboon, lion, giraffe, and antelope, can be easily distinguished. There are drawings of the square-nosed rhinoceros, which has not been known in Africa in historic times; and there are pictures of red-coated soldiers which must have been done by artists of the last hundred years. The figures are colored black, red, brown, or terra-cotta. It has been suggested that these are also parts of a picture language such as that used by the North American Indians.

From their stories and pictures and customs we find that the Bushmen have a shadowy belief in spirits and in a life after death. At the grave they talk to the spirit that has gone, and they have a beautiful proverb, "Death is only a slumber."

THE HOTTENTOTS

FROM earliest times the Hottentots have lived in South Africa. They are found scattered in groups up into the very heart of the continent, and in some places along the western coast. They are not dark like the other African natives, but yellowish, more like the Chinese. Having long mingled with the Europeans, many of them now wear European clothing. They do not like regular employment, and when they enlist in the army it is generally with the understanding that they shall fight only when it seems good to them, and run away when they feel like it.

The Hottentots rove about, living a few days in one place or a few years in another. Their common huts are round, cage-like frames, covered with mats or skins, and can be taken down or put up very rapidly. They are warm and fairly water-tight, but these very qualities which keep out the wind and water also keep in the smoke of their fires, so that nobody

SAVAGE ISLAND BOAT, WITH OUTRIGGER

The ingenious device of the outrigger was early introduced, by which the long, narrow boats, dug out of tree-trunks or made of bark or reeds, are kept upright.

but a Hottentot can stay long in a Hottentot hut.

When these people can get food they are enormous eaters. When an elephant or any other large animal is killed, the people of the kraal, or village, as soon as the news comes, strike their tents, and remove to the neighborhood of the animal, finding it easier to take their houses to the game than to bring the game home. The meat is roughly boiled, and the men, women, and children eat until full. Then they throw themselves back and sleep a few hours, only to wake up and again attack the food until the bones are picked clean. A Hottentot can sleep at any time. If he has plenty to eat he is forced to sleep. If he is hungry he sleeps as a relief.

AMUSEMENTS

Their common amusements consist chiefly in singing and dancing, and playing a curious instrument called the Goura. In dancing they join hands and form a circle. They turn round from one side to another, separating at certain intervals to mark the measure, and then from time to time clap their hands and chant, "Hoo! hoo!" Sometimes one of the dancers goes into the center and performs there alone a few steps after the English manner. Then they all drop hands, follow one another carelessly, with their heads leaning on one shoulder and their eyes cast down on the ground. A moment later they break forth in great joy and merriment, and the dance is ended.

There is a curious dance, much liked by the Hottentot girls, called the Melon Dance. In the evening, when the air is cool, the girls gather and choose one of their number as a leader. She takes a small round melon in her hands, and begins to run in a circle, waving her arms. The others follow her and imitate her movements. While running she flings the melon in the air, catches it, flings it again, and at last stoops suddenly, leaps into the air, and throws the melon beneath her towards the girl who is behind her. This girl has to catch the melon without stopping from her course, and the first has to throw it when she thinks that the second is off guard. So she pretends to throw it several times before she actually does. If the second

FIJIAN DOUBLE CANOE

A plan adopted by some modern boat builders.

Ewing Galloway

AFRICAN PYGMIES CONTRASTED WITH A WHITE MAN OF AVERAGE SIZE

girl fails in catching the melon the first continues as leader, but if she succeeds she becomes leader. In this way the melon goes round and round, and the sport is continued until the dancers are tired out.

The Hottentots have no idea of the division of the day into hours. If a man asks a Hottentot how far it is to such a place, he either makes no answer or points to a certain spot in the heavens and says, "The sun will be there when you get to it." Their folklore, like that of the Bushmen, is rich in animal stories of the "Uncle Remus" type.

PYGMIES

WHEN you see a dwarf in a company of men and women, you notice that everyone turns to look at him. It is not a common sight with us. Yet in South and Central Africa, and in some of the Pacific islands, there are whole villages of these little men and women, or Pygmies, as they are called, none of them much more than four feet tall.

APPEARANCE

In many ways they are like the Bushmen and Hottentots, but the color of their skin is paler, almost yellow, and their hair is short and woolly and black. They do not tattoo themselves, as do their taller neighbors, and they wear but few ornaments. The men wear arm-bands and leg-bands of braided fiber, and sometimes necklaces of seeds, scraps of broken shell, or teeth of kangaroos. How would you like to wear a string of kangaroo teeth around your neck?

Ewing Galloway

ZULUS OF SOUTH-EAST AFRICA AND THEIR THATCHED HUTS

They pay very little attention to the matter of clothes, but always carry a bag slung across the shoulders, usually hanging down the back, and sometimes a second one hung over the chest. In these bags the Pygmy keeps all his goods — his sleeping mat, his bone and shell ornaments, his knives, his firestick and rattan, and his bow and arrows.

THE WAY THEY LIVE

A common method among them of making a fire is to pass a rattan line round a piece of dried branch, holding the branch down with the feet, while the line is rapidly worked back and forth with the hands. Flint and steel are also used.

The Pygmies never cultivate the soil, but support themselves chiefly by hunting and trapping and by the preparation of palm oil. They use small bows and tiny arrows, which they can shoot with great skill. The woods in which they live are so filled with their traps that a stranger dares not walk in them, lest he tumble into a pitfall prepared for the leopard, wild boar, antelope, or monkey.

As a rule their homes are better than those of the taller people around them. The houses are built on piles, which raise the floor of the house from four to ten feet above the ground, according to the steepness of the slope underneath. The walls are made of laths of split wood, with big sheets of bark fastened on the outside. The roof has a steep pitch, and is covered with palm leaves. The floor is made like the walls, having a carpet of bark. In the middle of the floor is a square sunken box filled with sand or earth, in which a fire is kept burning; and from the roof above the fire hangs a rack on which wood is placed to dry. The houses are entered by a steep ladder made of two posts tied closely together, which leads to a narrow platform, or balcony, in front of the house. There are no notches on the posts, but the lashes of rattan which tie them together answer the purpose of steps or rungs for the feet.

The Pygmies are very timid, and it is hard for travelers even to catch sight of them, especially of the women, for they will dash into the woods and hide the moment they see a stranger approaching. Their knowledge of the woods makes them good spies or scouts, and some of the richer, more prosperous tribes employ them to guard the frontiers. They are regarded as kindly little people whose special mission is to provide the surrounding tribes with game and palm oil. In spite of their timidity, they have a keen sense of humor, comic ways, and amazing talent for mimicry.

SOLOMON ISLAND WARRIOR

THE FUZZY-HAIRED PAPUANS

THE Papuans are a branch of the Oceanic Negroes. They live on islands in the southern Pacific Ocean, chiefly on Fiji, New Guinea, and the chain of islands lying east of Australia and extending northwest to the Philippines. Perhaps the Nicobar and Andaman islands ought to be looked upon as belonging to the same people. The name "Papua" comes from a Malay word meaning "woolly" or "fuzzy," and was given to this queer race on account of their great mop of hair.

APPEARANCE

The color of the Fijians is a chocolate-brown. There are, however, two shades very clearly marked, like the blonde and brunette complexions of the white race. A Fijian's hair is stiff and wiry, and he trains it to stand out at right angles from the skin. About one third of the hair around the front of his head is of an ashy or sandy color and the rest is colored black.

It must be rather troublesome to keep this heavy mop of hair in order, and as a matter of fact the men of Fiji spend a great deal of time in dressing it. Nearly every chief has a hairdresser who operates upon him every day, sometimes for several hours. A chief sometimes protects his hair by a kind of turban, made of very delicate bark cloth, as thin as gauze. The Fijians are all fond of wearing flowers. They use them as hair ornaments and weave them into belts.

POLITENESS AMONG THE FIJIANS

They are fond of feasting and giving entertainments on a large scale, and on these occasions their manners are extremely polite. Everything is done according to a strict code of etiquette; indeed, they are among the most ceremonious people in the world.

When two people of equal rank meet early in the day, the correct phrase is, "Awake!" or "You are awake!" In the evening they will say, "Sleep!" or "Go to sleep!" In offering a gift they say, "I have nothing to offer you but this gift as an expression of my love for your children."

CANNIBALISM

You have all heard of cannibals, that is, savages who eat human beings. You will be surprised to hear that these Papuans, who can be so polite to one another, were, until within recent years, given to this dreadful habit of cannibalism. The idea of eating others was that when a man ate another man he acquired the victim's qualities, physical strength, courage, cleverness, or cunning. Since the coming of the missionaries to the islands the Fijians have largely become Christians, and have given up cannibalism and almost all their other barbaric customs.

ONE WAY TO REMEMBER

In their savage state these people have no idea of writing. Accordingly, when delivering a message, they use a bundle of sticks, no two being of the same length. Each stick answers to one of the terms of the message, which is repeated once or twice to the ambassador, who reckons them over on *his* sticks. When he in turn delivers his message to his chief, he unties the bundle, selects the sticks in order, and laying them down one at a time, delivers the message without a mistake.

FISHING AND FIGHTING

The Papuans are expert fishermen. Nets, weighted at one edge with shells and floated at the other with pieces of light wood, are much used; and so are the hook, the creel, and the weir. The principal use of the net, however, is in turtle fishing. The best example of the Fiji canoe is the double one, where two boats are placed side by side in such manner that one of them acts as the outrigger and the other as the canoe. The two canoes are covered over to keep out the water, and are connected by a platform which projects over the outer edges of both boats.

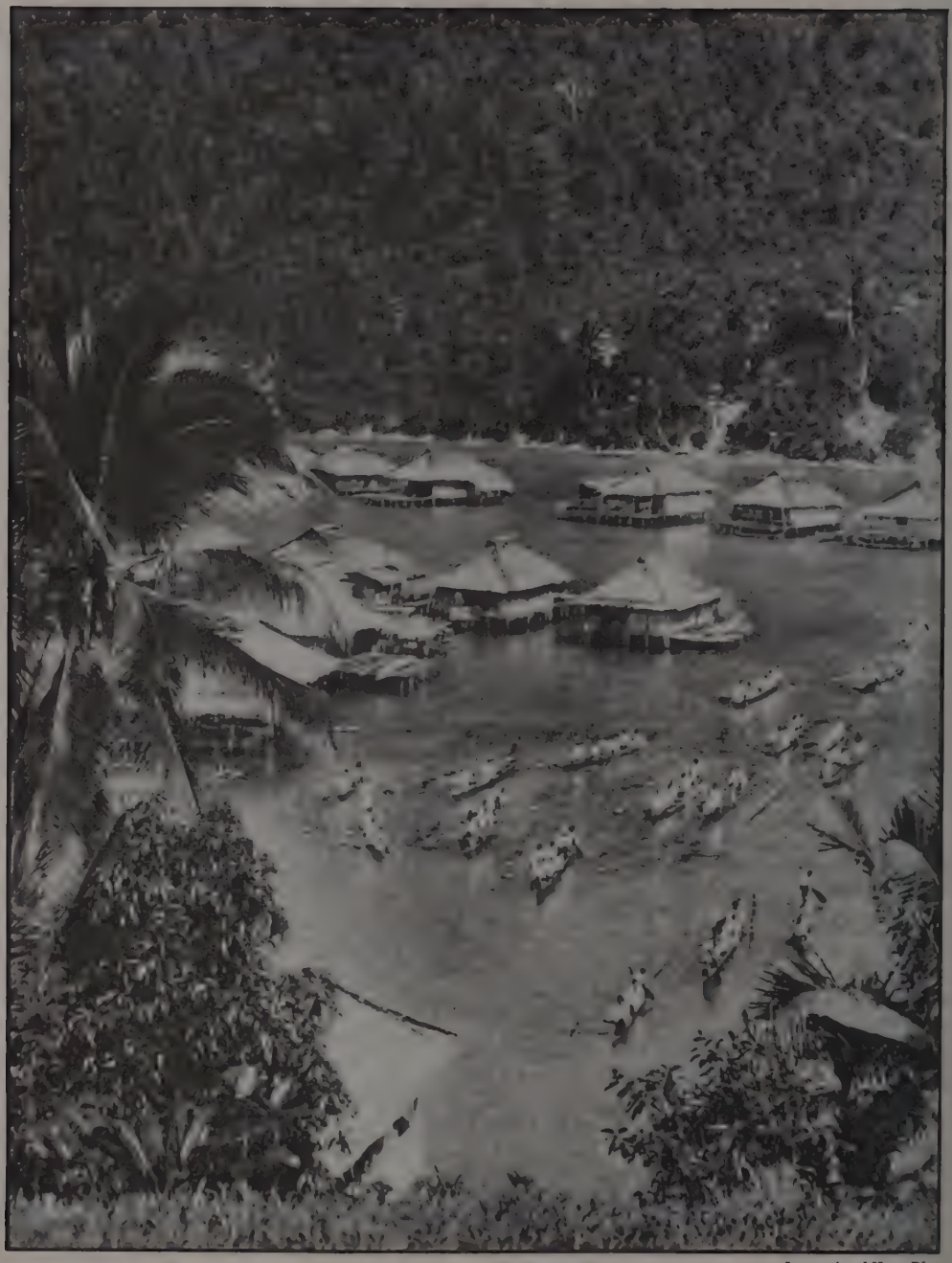
Their weapons are the club, the ax, the bow, the sling, and the spear. When two chiefs have decided to go to war, messengers pass between them, and both sides beat up recruits for their armies and offer gifts to the gods. Whales' teeth and food are the chief offerings. They have a curious custom of giving a new name to men who have killed any of the enemy during the campaign. Should one kill a chief, he takes the name of his victim.

PAPUANS AT PLAY

The Papuans have many amusements. Some of them are the same as our children's games, such as cat's cradle, hide-and-seek, blindman's buff, and a sort of hop, skip, and jump. Pitch and toss is also played, the round fruit of a species of mimosa being used instead of coins.

H. Armstrong Roberts

PAPUAN CHIEF IN FEATHER HEAD-DRESS, PORT MORESBY, NEW GUINEA



International News Photo

PAPUAN HOMES AND CANOES

Then there is the swing. The rope has a loop at the end, into which the swinger places his foot. Sometimes it is a large knot, on which both feet can be supported. Drawing the rope to the top of a convenient bank, the swinger grasps it with his hands, leaps into the air, places his foot on the loop, and goes sweeping through space often at a distance of fifty feet. An amusing game is often played by the young men. A thin earthenware vessel is filled with water and hung from a bough of a tree, and a number of young men with their eyes blindfolded try to break the vessel by striking it with long sticks.

There is one missile used by the native Australians that is popularly called the "kangaroo-rat," on account of its leaping power. It is a piece of hard wood shaped like a double cone, having a long, flexible handle about a yard in length. At a little distance it looks like a huge tadpole with a long tail. In throwing the kangaroo-rat the native takes it by the end of the tail and swings it backward and forward so that it bends quite double, and at last he gives a sort of underhand jerk and lets it fly. It darts through the air with a sharp hiss like the sound of a rifle ball. As soon as it touches the earth it springs up and makes a succession of leaps, each less than the preceding, until it finally stops. In fact, it skims over the ground exactly as a flat stone skims over the water.

CURIOUS CUSTOMS

There is a curious custom among the Papuans of New Caledonia. When two people meet they exchange their *katas* (or little scarfs), in the same matter-of-fact way that we shake hands. A New Caledonian also drinks in a very odd fashion. He does not lap up the water, or carry it to his mouth with his hand, but throws it into his mouth out of the hollow of his palm so recklessly that the greater part of it is splashed over him.

The New Guinea Papuans are great climbers, and their antics among the branches of the trees are wonderful. They will climb and spring from one branch to another almost like monkeys, and indeed, like those animals, when attacked, will take to the trees, where they can defend themselves with the greatest chance of success.

THE POLYNESIANS

THE Polynesians inhabit the South Sea Islands and New Zealand. Strange as it may seem, these uncivilized people belong to the Caucasian or white race, as is shown by

CARVED WOODEN DISH FROM HAWAII

their well-shaped Caucasic features. They have been called one of the finest races in the whole world. Visitors to Samoa, Tahiti, and the Tonga or Friendly Islands have spoken of the handsome, well-built, and splendid-looking natives, so similar in type to Europeans. They are clean and tidy in habits, with a sense of order and neatness seldom found among barbarous peoples. They are hospitable, courteous, and honest. Robert Louis Stevenson, the famous author, who lived on the island of Samoa for several years, was very much attached to his Samoan friends.

Most of the Polynesians have been converted to Christianity. It is said that everyone on the Tonga Islands can write; and this is doubtless true, since the missionaries, as we know, always bring to the natives education as well as religion.

SPIRITS EVERYWHERE

It is impossible not to feel interested in a people who were accustomed to think of themselves as surrounded by unseen forces, who saw in the rising sun, the silver moon, a shooting star, the meteor's transient flame, the ocean's roar, the tempest's blast, or the evening's breeze the movements of mighty spirits. The mountain summit and the fleecy mists that hang upon its brow, the rocky defile, the foaming cataract, and the lonely dell were all regarded

as the abode or resort of these invisible beings. The moon in an eclipse was under the control of some evil spirit, and prayers were offered up in the temples for its release. Others believed that the moon had been swallowed by the angry god which it had offended. Then many more must be the presents offered to persuade the angry god to abate his anger and eject the orb of night (or of day, for the same thing happened if the sun was eclipsed) from its stomach.

IDOLS OF OTHER DAYS

In addition to all these deities there were certain spirits who were supposed to be half human and half divine. These spirits were mostly demons, who often became angry and would not be calmed without the aid of the priests. The images of the gods were very crude, made out of rough, unpolished logs wrapped in many cloths, and bound with a finely braided network of cocoanut work ornamented with red feathers. Into these images the gods at certain seasons were supposed to enter; and though the images were among their most sacred things, yet after the gods had departed out of them they were comparatively powerless in themselves. Some of the Polynesians reverenced lizards, others sharks and various kinds of birds, usually in the belief that the gods entered the bodies of these animals.

SURF SWIMMING BY THE POLYNESIANS

Men, women, and children in Polynesia spend much of their time in the sea, diving, swimming, bathing, and sporting in the foam of the surf and great breakers which roll in upon the coral strands of these islands. The wilder the sea the more are they in their element. They usually select the openings in the reefs or entrances of some of the bays for their sport, where the long, heavy billows of the ocean roll in unbroken grandeur upon the reef or shore. They use a small board, swim quite a distance from the beach, sometimes nearly a mile, watch the swell of the wave, and when it reaches them, resting their bosom on the short, flat-pointed board, they mount on its summit, and amid the foam and spray ride on the crest of the wave to the shore. When they approach the shore they slide off the board, which they grasp with the hand, and either fall behind the wave or plunge towards the deep, and allow it to pass over their head. Sometimes they are thrown with violence upon the beach or among the rocks on the edge of the reef. So much at home, however, do they feel in the water, that it is seldom any accident occurs. Often from fifty to a hundred persons, of all ages, may be seen sporting like so many porpoises in the surf, while by their shouting they make more noise than the roaring of the sea or the dashing of the waves.

This shouting has sometimes a purpose, to frighten away sharks, which are the one great danger of this fascinating sport. But sometimes they are not so easily scared off. The cry of *mao*, or shark, is the most terrible sound that a swimmer can hear, and many a gay party has been broken up by this call.

ATHLETIC GAMES AMONG THE POLYNESIANS

Athletic games are popular with the Polynesians. Skillful wrestlers obtain great honor and renown over a long stretch of island-dotted sea, though champions are not long permitted to enjoy their position undisputed, for if it is once known that a visiting chief from a distant island has a celebrated wrestler in his train, the hero is speedily challenged to trials of skill.

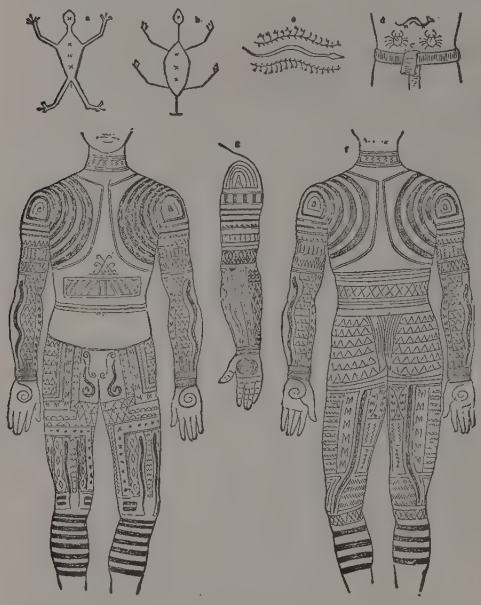
Boxing was an equally popular amusement in former times; even chiefs and priests were ranked among the most eminent patrons and champions. Foot races, in which the bodies of the runners were anointed with oil and their heads bound round with garlands of flowers, were also common amusements; while the martial games of throwing the spear or javelin at an opponent who skillfully caught it in his hand or parried the thrust with his spear handle, throwing stones from slings, archery, and mock naval or military combats, were indulged in by young and middle-aged men of all classes. Lighter games were football and ball throwing.

"SEIZING THE BALL"

In these amusements the girls were not neglected. For them there was a game of *haru raa puu*, or "seizing the ball," in which the men took no part. An open place was necessary

POLYNESIAN WEAPONS, BREASTPLATES AND WAR GODS

for all their sports, and the sea beach was usually selected. The boundary mark of each party was fixed by a stone on the beach, or some other object on the shore, having a space of fifty or one hundred yards between. The ball was a large roll or bundle of the tough stalks of the



AN ARTISTICALLY TATTOOED MAN

plantain leaves, twisted closely and firmly together. The players began in the center of the space; one party, seizing the ball, endeavored to throw it over the boundary mark of the other. As soon as it was thrown, both parties started after it, and, in stopping to seize it, a scramble often ensued. As the game progressed, the players frequently fell over one another in the greatest confusion, and in the general disorder arms or legs were sometimes broken. As the pastime was usually followed on the beach the ball was often thrown into the sea, where it was fearlessly followed. Amidst noise and cheering forty or fifty girls might be sometimes seen up to their knees or their waists, splashing and plunging in the water.

Dances of many kinds, performed in quaint dresses, to the sound of drum and flute, were a favorite recreation. Many games, such as archery, were held sacred. Before indulging in them the performers went to the temple to procure the favor of the gods by religious ceremonies. The king and the great chiefs usually attended a game of archery. As soon as it was over, the bow and the quiver of arrows, wrapped in cloth and held sacred, were committed to the charge of a special custodian. The archers repaired to the temple, and were obliged to change their dress and bathe before taking refreshment or entering their dwellings.

MUSIC AMONG THE POLYNESIANS

Musical instruments of a rude type are common, particularly drums and flutes, which are in great request at high festivals. Trumpets made of shells were used to summon combatants to battle, to blow when a procession walked to the temple, when a king was inaugurated, or during religious services. The sound is dismal and monotonous beyond imagination. These light-hearted people are also much given to singing. They have composed a surprisingly large number of songs, often sad and rather pretty.

TATTOOING

Tattooing is in great favor among all the principal groups of the South Sea Islanders, more especially among the Marquesans and New Zealanders. It is usually adopted as a personal ornament, although the tattoo may occasionally be looked upon as a badge of mourning, or a memento of a departed friend.

Tattooing was supposed to be invented by the gods. Two special deities were the gods of tattooing, and their images were kept in the temples of the professional tattooers, where petitions were offered that the figures might be handsome, striking, and successful.

Various methods of performing this painful operation are used. A thread is drawn through the skin with a needle of fishbone, and the skin being punctured, a black coloring matter is injected with other instruments. In New Zealand the operator taps a pointed instrument of bone on the design, which has been traced on the skin. When blood flows charcoal from the kauri tree is rubbed in, giving the desired blueblack effect. Our illustration shows the method. To

cry out or show signs of suffering is looked upon as unmanly, and a man being tattooed will often lay his head on the lap of his sister or some young relative, while friends chant aloud to drown any murmuring which the torture may accidentally draw from him.

This is the song that has come down from the ancient Maori: —

"What is the charcoal? Is it from the kauri tree?
Let us raise it so the spray will fall upon this man.
We call upon the Easterly wind, we repeat our call to the Easterly wind.
Let us spray it upon him, he wishes it to be put upon him,
From the land or from the heaven above.
Give me my love, let me have the honour of greeting him.
There are blossoms in the wind, there are blossoms in the air,
There are blossoms on the top of Rehia and on the top of Reao.
That is where all my thoughts are.
Don't be offended with me, don't be cross with me.
There are birds called the Huia,
The meaning of the name of Huia;
Let us all be together."

This was to show him that the correct ingredients were being used, as the kauri charcoal was handed down from father to son. The easterly wind was a favorable omen, and when he had been beautified his love would be proud to greet him. His thoughts were directed to the far-off mountains of Rehia and Reao, away from his present sufferings.

SAMOAN (POLYNESIAN) HOUSES

The houses look at a distance like large mushrooms, consisting simply of a thatch of the leaves of the sugar cane supported on three or four long upright posts, with a piece of matting drawn round the posts for walls. The floor is a hard pavement of gravel, and the living room is divided into sleeping rooms at night by partitions of cloth.

When the Samoan goes to bed, he places his head on what we should consider a hard pillow. It is a sort of stool, consisting of a carved piece of wood resting on four legs.

THE TAHITIANS

A well-known voyager — Dr. Pickering — speaking of the Tahitians remarked that he had never seen a people so serviceable to the traveler, for they seemed able to provide at all times the principal conveniences of life. "Half an hour of daylight was sufficient for building a house of the stems and leaves of the *fehi* banana, and fire was produced by rubbing sticks. In one place the running water was deeply sunk among the stones, but by working in banana leaves they brought it to the surface. The capture of eels, which in these dripping mountains become almost amphibious, offered another instance of their ingenuity. They also tore off with their teeth the fibrous bark of the *purau*, and a moment after applied it to noosing small fish. If one was sent for fruit, he would usually make a basket on the way, by plaiting the segments of a cocoanut leaf. A mat was manufactured with almost equal ease. Clothing was always at hand, and a banana leaf served for an umbrella; or, in fine weather, they would weave garlands of flowers. Tumblers and bottles were supplied by single joints of the bamboo, and casks or baskets by the long stems; and whether we asked for a hatchet, knife, spoon, toothbrush, or wash basin, we never found our guides at fault."

THE TATTOO ARTIST AT WORK

THE MAORI OF NEW ZEALAND

By Charles A. Wilson

A TALE OF LONG AGO

ON a South Sea Island — perhaps one of the Hawaiian Islands, perhaps any of the wonderful tropical islands of the Pacific — on a morning long before the dawn of history, the native village was astir.

The priest, who possessed such keen senses that he could actually smell or feel the presence of people miles away, had caught the odor of man in the fog at night, as he paced sleeplessly along the beach, and had warned his people to be prepared. These men who were coming over the water towards the island might be friend or foe.

The people, weapons in hand, lined the beach, straining eyes and ears to catch the first sign of the approaching boats. There, far off, now rising on the crest of a wave, now falling out of sight in its trough, was a big canoe. The watchers on the shore could see the brown backs of the rowers, rising and falling as they swung their paddles in rhythm with the chant of their priest, who paced up and down the narrow platform in the center of the boat. Nearer and nearer they came, until the people could see that these were no strangers, no foes to fear, but their own men, returning home after months of wandering over strange seas. They could hear the voice of the leader raised in a chant of triumph. Then, with a deep-throated roar, the hundred warriors and rowers broke into chorus as they drove their staunch craft into shallow water and the men on the beach rushed in, waist deep, to drag it to the shore.

What a homecoming! From the cramped quarters of the boat, the big, brown men stepped like victors and stood erect upon the beach. Imagine the little boys and girls running about excitedly, getting in the way! Imagine everybody excited, asking questions and hardly waiting for the answers before they asked others, all full of happiness because the quest was over and the warriors had returned!

There was no work done that day save cooking for the feast in which all joined. Far into that night, and on for days, the adventurers told their tales of the wonders of the far-off lands which they had seen. There was sadness, for some of the warriors had not returned. The sea had claimed them during a terrible storm, or they had been killed during the attack of some fierce tribe which came out from hiding on an island where they had landed, and drove them off, with heavy losses on both sides. So they wailed for their dead, as was their custom; and the mari-

ners must hear, too, of the deaths of the home people, and join in the sorrowing for them. But grief did not last long, for adventure and wounds and death were the daily lot of those who explored these wastes of water and dwelt on these islands in the days before history. Did not the gains outweigh the losses? Had not this exploring party found lands filled with birds and berries, and waters where one might drop an unbaited hook and catch great fish which were good to eat? The treasures were shown: the skin of a bird, the bark of a strange tree, a piece of stone so hard that a club or an ax made from it would long outlast the tools and weapons made from softer stones. Stories were told of giant birds, of demons that rose from the water, of beautiful, waving sea maidens that called the mariners on, of huge white peaks that seemed to pierce the domain of Rangi, the Sky God, and of great silent forests where only the cry of a bird or the moaning sweep of the wind broke the deathly stillness, and Tane, the Forest God, reigned supreme.

Perhaps in some such way the daring navigator Kupe, earliest of the far-traveling canoe men of the Brown People, returned to his island home and told the tales which were to lure his people out across the waters to new lands. He had watched the stars and could give the star signs by which those who wished could find their way across the trackless waters to the "Land of the Long, White Cloud," which was the name he gave New Zealand. In time the people left the smaller islands forever to settle in this wonderful land.

WHO WERE THESE BROWN PEOPLE, AND WHERE DID THEY COME FROM?

No one knows. That is why we must make a story of their coming to New Zealand, which is the farthest south of any inhabited land, four thousand miles south of the Hawaiian Islands. Four settlements of Brown People were made in New Zealand at different times. One record tells of the Great Fleet, with seven or more canoes which brought them from Hawaiki, which means in the native tongue the "Home land." But where, in the wide sweep of lands encircling the Pacific, the home land was, no man can tell.

We know these Brown People as the "Maori," but that word, too, tells little. When the Europeans came and asked their name, the many tribal names (like those of our American Indians) confused them. One word stood out, the word "Maori," meaning "artisan," or "worker." The Europeans gave that name to them all.

The land was not uninhabited when the Maori came to it. The Toi people, of a more peaceable nature, had records going back a thousand years. There were traces of another, a lighter-skinned people, before them, and still further back were the Moriori, who are supposed to have written on the rocks inscriptions like those of the North American Indian. (We shall tell you shortly the story of a single Moriori who is to-day the last of his race.)

But the new arrivals were more warlike than the people they found. The Toi tribes who were living there did not eat human flesh. The Brown People were cannibals, and fierce warriors besides. Savage fights took place when the newcomers tried to take the land, and the weaker peoples were driven out and took refuge on the South Island, which is colder than the North Island where they had lived. (The land from North to South, with its two very large islands and a smaller one at the foot, is twelve hundred miles long, and could give room for a great many people.)

THE COUNTRY

When we speak of a native people, we wish to learn where and how they lived and what they did in the centuries that passed before the white men came and taught them new ways.

New Zealand is a very hilly place, with many high mountains, some of which are covered with snow at the tops. There are many lakes and rivers on each island. These were welcome to the Maori, who were skillful with the canoe and used the rivers and lakes as roads for travel.

The climate in the upper part of the North Island is very mild, like that of California. It becomes colder as one travels south — this is the region, you remember, approaching the South Pole — until, at the very southernmost end of the country, the winters are quite severe. The Maori, coming from the warm Pacific, naturally loved the milder climate. Their native huts were not very warm. The soil of the North Island was easy to work with wooden spades

and good for the growing of their only vegetable, the sweet potato. It is not difficult to see why they fought to secure these lands.

THEIR VILLAGES AND HOUSES

The villages, or *pahs*, were nearly always built on a hill, so that from them an enemy could be seen when he was far away. The *whares*, or houses, were grouped in rows around the hill. A palisade of stout tree trunks was set up on the outside. Within it was a row of huts. Then another inner palisade; then another row of huts. A third palisade protected the inner fort, or citadel. When a village was attacked, its defenders could fight from one barrier to another, and finally make a last stand at the top. The Maori were skillful fighters. In the wars that took place many years later between them and the Europeans, the soldiers had much trouble, even with big guns, in conquering these *pahs*. Each palisade had its watch towers where men stood guard night and day, reporting any signs of a lurking enemy.

The houses were not large, each holding but one or two families. They were built chiefly from *raupo* (raoo-po), a thick-bladed kind of rush which grew in great quantities in all the swamps, and *manuka* (ma-noo-ka), a shrub that grows to six inches in thickness. The thinner kinds of rush were gathered in long bundles, and set on end and laced between the wooden supports of the house. A kind of flax which could be readily torn into strips took the place of rope for the lacing. (From this fiber the Maori also made their clothing, dyeing it with native tree juices.) For the wooden framework the forests supplied trees of all sizes, but these had to be cut down with great labor with crude stone axes. Nearly all the houses had small storehouses set on one or more poles, so that the rats and other vermin could not get at their food.

The great Meeting House, where the councils were held, was a large, well-built structure, the flat boards and door-frames of which were often beautifully carved and decorated. Here hundreds of natives could squat on mats on the floor, listening to the speeches of the chiefs and priests.

There was also a House of Learning, where the chiefs and priests instructed those who were selected to learn the sacred mysteries of their religion and become chiefs and priests themselves. For the ordinary people there were classes in the ways of Nature. All learning was handed down by word of mouth, as there was no written language.

The people held their sports and performed their dances or warlike exercises in the open.

NATURE LORE — STAR STUDY

The Maori knew much of Nature, to which he was very close. He loved the land, and every bush and rock had a meaning and a story for him. All knowledge was shared as it was found out, and the people became very wise in the ways of the birds and fishes and the reading of weather signs. A man had to know these things, for on them depended his food supply. He watched the flowering of certain trees and learned whether he should prepare for a wet or a dry summer. He ate what was good in the berry or herb or fruit from the tree, leaving what was poisonous. He cured simple ailments by brews from herbs and barks.

The stars were known to him by name; by the time of their rising and setting he planted his crops. He saw pictures in the heavens, Orion being likened to a bird snare, and other groups of stars to the canoes of famous navigators, who in long nights of traveling followed the direction indicated by the stars. If Canopus twinkled more brightly on one side than the other, the sharp-eyed Maori knew that the wind would blow heavily from that side. Mercury (Tariao) was the forerunner of the dawn. Guided by him, war parties stole out into the forest, and workers took up their wooden blades to cultivate the ground.

Great stores of star knowledge were imparted by the priests in the House of Learning, and the people listened eagerly.

WHERE THEY GOT THEIR FOOD

When the Maori came to New Zealand, they found there no four-footed animal life — no deer, no bears, no little animals of the woods — and no snakes or poisonous insects. The rivers and lakes were full of eels and small fish; the forests and plains had queer, wingless birds, such as the

Courtesy of Peabody Museum, Harvard University

A NEW ZEALAND VILLAGE — NATIVES IN NATIVE DRESS

moa, which was twelve feet high, and the smaller *kiwi*,[1] and the swamps abounded in geese and duck, swamp hens and swans. Numerous flight birds, which made the island a resting place on their migrations, were good to eat. The sea was full of fine fish. There were great, harmless sharks, the meat of which the Maori dried in great quantities for winter. The rocks were covered with shellfish; and the sands yielded shellfish in great numbers. The forests had berries, and the plains were covered with ferns, of which the roots were good to eat.

Cannibalism was practised, the people having the idea, common to many savage tribes, that those who ate the flesh of an enemy, especially of a noted warrior, would acquire his strength and powers. From this came the eating of human flesh when it could be obtained — a savage practise which was abandoned when the white man brought to New Zealand pigs and other food animals.

THE MAORI IN WAR

The Maori were bold, warlike, and savage. They fought for land, for slaves, for revenge, in tribal and family feuds that were carried on for generations, and last but not least, for the love of fighting. Yet they were not unreasonable. There were times when useless slaughter was stopped by agreement between the besiegers and the besieged. Sometimes, if an attacked tribe was short of food, the attacking enemy would stop fighting to send in food so that the warriors might partake and so have strength to renew the fight.

They did not usually fight in the open, but retired to their *pahs*, or forts, from which the

[1] See pictures of flightless birds, Volume Ten, pages 83–86.

WAR FLEET OF TAHITI WITH THE PRIEST IN THE PROMINENT POSITION

enemy sought to get them out. The attackers would dance before the walls and taunt those inside, until they became so angry that they rushed forth for revenge. Or sometimes there were those within who had relatives in the attacking party and would open a gate to let them in. An attack was heralded by the sound of the great war drums.

As the battle raged from slope to slope, houses left unguarded were fired. The warriors had few weapons. Long spears were used to poke through the palisades, and there were war clubs. But in general it was hand to hand fighting, and was to the death. All the warriors were trained in fighting from their youth up, and looked on a battle as a chance to show their skill and gain prestige in the tribe.

Often they came a long distance to make their attack and approached a village in great war canoes, about eighty feet long, which carried a party of one hundred and forty or fifty warriors. On such expeditions these canoes were decked with feathers and ornaments on the stern posts and the bows.

BUILDING A WAR CANOE

Canoe building was a very important work, and took a great deal of time and skill. The growing tree was selected in the forest, and felled to the ground by slow labor with stone axes, wedges, and adzes. Then the branches had to be chipped off, and the bare trunk taken to the spot where it was to be fashioned. Each of these operations was supervised by the old *tohunga* (to-hoong-a), or priest, who made an incantation to the Forest God, who was being deprived of one of his children, and to various other gods concerned, those in charge of the undergrowth and of the elements of fire and water.

Slowly the tree was dragged to the place of work, and the builders were prepared by ceremonies for the important task which was to be theirs. No outsider might so much as touch a chip. They were all gathered by the builders and burned in a sacred fire.

The upper surface was stripped of bark, and a row of shallow holes chipped in it for its entire length. A fire was lit in each hole. As a hole charred, the fire was lifted, and the stone adze

used vigorously on the burnt wood. By repeated burning and cutting away of the burnt wood, a large hollow was soon made. When the fire had done all that was possible, the rest of the inside of the huge log was chipped away with stone tools.

The keel of the boat was then started. After it was shaped to suit the man in charge, the canoe was tried in the water for speed in paddling. It might be pulled out of the water and brought back again and again, until it could be paddled to a set mark in the shortest possible time.

The big war canoe was then fashioned stem and stern, with decorated beautifully carved stern-posts and head-posts. A flooring was laid; seats were made for the paddlers; and a platform was placed in the center on which the priest would walk up and down, chanting to encourage the rowers. Paddles were fashioned, all dedicated to their work by special preparation and ceremonies.

Many months' labor was required to make a canoe of this kind, but when it was completed it swept out over the waters, a thing alive.

WOOD CARVING

In wood carving the people excelled. It seemed as if they could not bear to use a plain article; every implement, however humble, was carved with some design. Upon their canoes and paddles, the staffs used by their priests, and their sacred houses and door lintels, they spent years of loving labor.

To-day this art is being revived. With the aid of steel points the young Maori can produce beautiful work in a fraction of the time occupied by their ancestors.

WOVEN MATS AND BASKETS

The native flax, of which there were hundreds of acres, served many purposes. When the women had gathered the shellfish on the beaches, and picked, or taken from the storehouses, the sweet potatoes which were their staple vegetable, they cooked them over heated stones in earth ovens. Over the stones was laid a flax mat. Then a layer of food was spread, and a second flax mat put over it. Earth was heaped on top

MAKING EARTHEN POTS

Courtesy of Peabody Museum

MAORI CHIEFS

Notice the two types of face: that of the man on the left (holding the whalebone club) is long and narrow, that of King Tarrhair (right) is broader. The lines are tattoo marks.

to hold in the heat. After the food had cooked for the proper length of time, it was brought out and piled on flax mats, one or more for each family in the tribe. When the meal was over, there were no dishes to wash, as the mats were tossed in the fire and burned.

These mats were quickly made, as were the sleeping mats. But when the more arduous work of the day was done, the women sat in circles and plaited the finely scraped flax fiber into beautiful, finely patterned mats and wearing apparel. The inner fiber, used for clothing and dyed in bright colors from plant dyes, was treated until it was as soft as silk.

WEAPONS AND TOOLS

The Maori knew nothing of iron or steel. He did what all primitive tribes have done, made his weapons and tools from chipped stone. This was a never-ending work, for they were always being ground down by continual use. For the making of such a war canoe as has been described, many hundred would be needed. Every tribal undertaking meant the making of a large quantity of implements with which to carry it through. War clubs, axes, adzes, and woodworking tools were those most commonly made.

Then, ornaments were worn by both men and women. These were often made from greenstone, a kind of jade found only on the South Island. It is so hard that modern stone-workers have difficulty in cutting it with their sharp tools. Yet the Maori managed by working steadily at it with their crude tools to fashion it in many shapes and polish it like glass. Only men with great skill and unlimited patience could have accomplished what these stonecutters did.

Courtesy of Peabody Museum

WOMEN IN NATIVE DRESS

Notice the same two types of face. The girl on the left wears a jade pendant and carries a jade club.

TATTOOING

The process of tattooing has been described as it was practised by the Polynesians. The Maori warrior had his face tattooed that he might be handsome and distinguished in appearance. The designs were made from forehead to chin, down the center of the face, each section having a special name. In some cases the whole of the face was elaborately ornamented. Women were tattooed all round the mouth and on the chin.

PROPERTY IN COMMON

The Maori had few possessions save his weapons of war and his household goods, most of which he made himself. All was held in common by the tribe. A man might have a clearing on which he grew food, but it really belonged to the chief as representing the tribe. Every Maori was required to know the title by which his piece of land was held, whether by original occupation, by conquest, by purchase, or by gift.

MUSIC AND DANCING

There were three musical instruments, a rude war drum, a trumpet, and a flute. This last was a hollow tube of wood, held upright, and blown across the top. The notes were produced by stopping the other end with the big toe, as the musician squatted on the ground. The result might not be music as we know it, but it was sweet to the ears of the listeners. Good flute players were highly regarded in the tribe.

Dances were ceremonial, having a definite purpose and meaning. The men's dance was the *haka* (hah-ka), a war dance of a fierce nature,

MAORIS IN WESTERN DRESS

designed to excite the warriors before battle or to frighten away the enemy. Whatever form it took, the effect was awe-inspiring, as the huge Maoris jumped up and down in the frenzy of the dance, thumping the earth with their bare feet, thrusting out their tongues, rolling their eyes, and brandishing their weapons. The women's dance or *poi* was performed while the women held in their hands the two ends of a string to which *poi* balls (reed balls containing a seed or pebble) were attached. The movements of the dancers were graceful and pleasing, and the cheerful tapping of the *poi* balls made music to Maori ears. Both men and women accompanied their movements by chanted words descriptive of the reason for the dance.

THEIR RELIGION — THE LAW OF TAPU

The religious character of the Maori has been shown by the many ceremonies attending important events. They had many gods, but did not make idols, as some primitive peoples do. They recognized a supreme god, Io, with whom superior people had to do. To ordinary persons this being was only a name to be mentioned with awe. For them there were the gods of Nature, the gods of Sky, Sea, Forest, and Wind, the god of War, and the many spirits to whose influence natural happenings were supposed to be due.

The supreme law was that of *tapu* (tah-poo), known as "taboo" in our language. This took the place of a civil law, which the Maori did not have. The word means "sacred" and also "forbidden." A chief's back was *tapu*, or sacred; he could not bear burdens. The priest was exceedingly *tapu*. While he was carrying out certain long and important ceremonies, he could not even touch food with his hands, but was fed by a child, who was regarded as near to the gods and therefore pure. Curses were chanted to frighten the people who might be tempted to disregard the *tapu*. Such disobedience was often punishable by death.

Tapu was very convenient for many practical purposes. It was used to protect certain regions so that birds or fish might not be taken out of season. It made sacred those engaged to work on the sacred house, thus freeing them from other duties and from interference. But, like many codes of detailed laws, it was abused. The people became bewildered because of the many *tapus*, and lived always in fear of breaking one.

Yet the Maori were and are, as a whole, a happy, contented, hard-working people. With the coming of the white man and their contact with him, they have given up most of their savage ways. To-day they have become civilized, and live at peace with one another and with their white neighbors.

THE ETHIOPIANS AND BANTUS

AFRICA is a land of contrasts, a land where the time-line of history has been shortened by the coming in of the white men. In some ways the simple, native peoples have been brought forward five hundred or a thousand years along the road to civilization within a short period of from fifty to seventy-five years or even less, through their contact with the whites.

We began this story of "Interesting Peoples" with chapters on three groups of the early inhabitants of different sections of Africa, the Bushmen, the Hottentots, and the Pygmies, telling about their primitive life as if it were still separate from the rest of the world. Yet even as we tell of these simple peoples and their tribal customs, we know that into their villages and homes are coming new influences from the strange life of other regions and of the great cities.

Of this meeting of the old and the new there is no better example than the Ethiopians, lately brought to the world's notice through their heroic but unsuccessful effort to maintain the independence of their ancient kingdom. The Ethiopians are a proud people, dating their history back to the Old Testament times of King Solomon. Haile Selassie, whose picture is shown here, was crowned on a November day in 1930 as "His Imperial Majesty Haile Selassie the First, King of Kings of Ethiopia, Conquering Lion of the Tribe of Judah." He traced his ancestry and these proud titles back to the dynasty of Menelik the First, who was born of Solomon, King of the Hebrews, and the Queen of Sheba.

When he was crowned it was a Christian coronation, with the ceremonial of the ancient Coptic church, to which Ethiopia turned hundreds of years ago, taking the place of the old Judaic customs. He was the three hundred and thirty-fourth of all the kings of Ethiopia and the one hundred and thirty-fourth of the Christian kings of that country. The land which he ruled for a brief space was part Christian and part Moslem in its population.

At that coronation the men escorting their king to and from the palace wore headdresses and collars made from lions' manes, symbol of an old tradition. The villages in the highlands used in days past to be in constant danger from the ravages of lions, and it was the duty of the ruler of the country to encourage his fighting men to defend their own villages. Hence, there grew up a custom that any Ethiopian who killed a lion had a right to an audience with his king, at which he might describe his feat and from which he went out with the privilege of wearing the lion's mane as part of his costume.

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HAILE SELASSIE

As he appeared at his coronation in 1930.

Some of these warriors still carry the old-time spear but many now have modern rifles. The white men brought rifles, railroads and radios to Ethiopia in exchange for coffee and the other products of the country. But they brought also many less desirable things: Wars and hatreds and a more or less complete loss of independence for this ancient and proud race of black-skinned people.

The Bantu tribes are another example of change in Africa. They are changing over from their old life in *kraals*, or farming villages where they lived in a tribal fashion, to a new existence in gold mines and other employments which mass them in huge communities of workers. The Bantus are Negroes living chiefly in eastern and southern Africa. Travelers tell of the great Mlengara Rock which stands alone and forbidding in Zululand, from the summit of which it was the custom in the not-far-back days of savagery to hurl men to death at the command of a powerful chief. A whole regiment, by such orders, once climbed to the top of this rock and hurled itself to death. But the great-grandsons of those men are very likely sitting today in their *Bunga*, or Parliament House, not thirty miles away, managing their tribal government in the fashion of representative assemblies which it took our forefathers a thousand years to work out.

Johannesburg, metropolis of South Africa, is a modern city, with wide streets, business blocks, fine residences. It has been built within the last fifty years above an ever enlarging underground mining city, where two hundred thousand men, most of them Bantus, spend their lives mining the gold which makes up half the world's normal supply of that precious metal.

It is a difficult change that the young people of these African tribes and peoples are making so suddenly. From foot travel on their jungle and forest paths where fifteen miles per day is high speed, a youth may come out to work in a machine shop to which he drives his own automobile. Their religion of superstition and fear goes, but with it depart also many of the wise tribal customs of honor and obedience to their elders.

They are meeting it well, these boys and girls of many different racial strains. But one feels it is not all gain to live in a country where are found the largest copper deposits in the world, most of the world's supply of radium, and a hundred other precious commodities, besides the familiar gold and diamonds. Missionaries, doctors, nurses and teachers from Europe and America join with the business men who seek this wealth in trying to give to the native peoples the best of our modern civilization into which they have been thrust so suddenly.

THE WORLD-WANDERING GYPSIES

Gypsies have always been a mysterious and fascinating race. They have no settled home, but roam about the world wherever their fancy takes them. Bands of them have traveled through all the countries of Europe and many have come to America. There is a wild strain in the gypsy blood that delights in the freedom of the open road, and dislikes nothing so much as dwelling between the four walls of a house. Of course during the winter they go into the towns and become house dwellers, but with the first spring sunshine comes the longing to be off on the road.

Who are the gypsies? They are really Hindus, or natives of India, having first appeared in Europe about 1320. Gradually they were dispersed over the different countries of Europe, partly because of the severe laws that were passed against them. In each country they were known under a different name. The English thought them Egyptians, and named them "gypsies," as they probably reached Britain by way of the Mediterranean from Egypt. These wanderers became nationalized to a certain extent in the countries in which they took up their abode. Thus English gypsies are a very distinct class from the continental gypsies, and when they migrate they always go to an English-speaking country. There are certain well-known families of English gypsies who long ago adopted the surnames of Stanley, Lee, Cooper, Boswell, and Lovell, and we meet many of their descendants in America. In former times we heard of "gypsy kings" and "gypsy queens" ruling over the various bands of wanderers, but these romantic beings have now quite passed out of gypsy life. The most famous name in the gypsy annals is that of John Bunyan, the author of "Pilgrim's Progress," who is said to have been the son of a gypsy tinker.

At country fairs gypsies are frequently to be found, driving a flourishing business in toys and small wares. Most of the women are adept at fortune telling, to say nothing of begging. Some bands of gypsies own and operate their own traveling carnivals. Gypsies have been known to grow very wealthy in these and other employments. The wealthy members

of the tribe have their vans and tents luxuriously furnished with carpets, blankets, linen, and silver, and silk gowns and jewels are not unknown among their families.

The gypsies have a distinct language of their own called Romany, which they guard jealously from the "gentiles," as they term people of other races. They pride themselves on the supposed fact that only persons of their own blood can speak this ancient tongue, handed down through many years from father to son. Yet many of their modern descendants can speak hardly a word of it, while various "gentile" scholars have completely mastered it. A gypsy has the greatest respect for an outsider who understands his language, and is sorely puzzled to know how he came by it. To be able to *rakker the jib*, however little, is often the passport to an invitation to his tent. He suspects that the stranger is a "gentleman" of gypsy blood and is delighted accordingly. To such a person he applies the term "Romany Rye," or "gypsy gentleman." A student of gypsy history and writer of gypsy romances was George Henry Borrow, whose "Romany Rye" is one of the great stories. An American writer, Charles Leland ("Hans Breitmann"), was a celebrated Romany scholar and a great friend of the gypsies.

MISREPRESENTATIONS OF THE GYPSIES

A great deal has been said and written about the gypsies, much of which is not true. For instance, they have been declared to have a habit of kidnaping children; but those who know the gypsies well say that they have no taste for this sort of thieving. They have enough to do to look after and support their own children. Simply because they lead a roving, vagrant life, they have been unjustly blamed for numerous cases of lost, strayed, or stolen children, and many imaginative writers have in their stories and plays turned the gypsies into kidnapers.

Do you know how many famous operas have been founded in part on gypsy life and characters? These operas are "The Bohemian Girl," "Carmen," "Maritana," "Mignon," and "Manru." Very romantic are the pictures they present, but by no means wholly true to life.

BEDOUINS

THERE is another wandering tribe different from the gypsies, yet like them in some ways. It is the Bedouins. But instead of wandering over all the world, they stay in their own country, and that is the Arabian desert.

The Bedouin is an Arab, but not all Arabs are Bedouins. The word "Bedouin" means "dweller in tents," and the Bedouin of to-day is a wanderer, or nomad of the desert, having for his home only a black tent made of goats' hair, the material for which is collected, spun, and woven by the women of his family. An Arab who lives in a house looks down upon a Bedouin, but a Bedouin feels insulted if one calls him a house dweller.

The Bedouins have no form of government, except that each family or tribe is ruled by a chief, called a sheik, who settles any difficulties that may arise. They have queer notions of hospitality. They will rob a traveler on the desert, taking even the clothes he wears, and then will invite him into their tents for refreshments. But if the traveler takes food or "eats salt" with them first, they will not rob him afterwards. We have all read old tales of fugitives who gained the shelter of a Bedouin tent, were invited to eat with the hospitable sheik, and were from that moment protected by him as his guests. No enemy could take them from his tent, save by force. To have given a man up to his pursuer after breaking bread with him would have been to violate the sacred law of hospitality.

The Bedouin women are very fond of jewelry. They wear headdresses, necklaces, nose rings, earrings, bracelets, and anklets of gold and silver. In fact, the Bedouin wealth consists chiefly in jewels and ornaments. There are no savings banks in the desert, and all the valuables these people can get hold of, are hoarded and hidden.

NOMADS OF THE DESERT

The desert is not, as one might think, a level, sandy plain. It is a wild wilderness of mountains and valleys, ever changing with the changing winds. Sometimes the sand is of a chalky whiteness; again it sparkles with mica and quartz, and again it is a golden yellow.

A CARAVAN ENCAMPMENT ON THE ARABIAN DESERT

The poet Story has described a desert scene in very beautiful words. He says:

"All around
To the bound
Of the vast horizon's round,
All sand, sand, sand,
All burning, glaring sand.

"Not a sound
All around
Save the padded heat and bound
Of the camel on the sand,
Of the feet of the camel on the sand.

"Not a bird is in the air,
Though the sun with burning stare
Is prying everywhere,
O'er the yellow, thirsty desert, so desolately grand."

And over this great highway of the camel the Bedouin is constantly traveling from one oasis to another, with no guide but the sun and stars, and sometimes with no companion but his beautiful Arabian horse, for on the Arabian desert are raised the most beautiful horses in the world.

The Bedouin leads a very simple life. His chief food is coarse bread and dates. If a Bedouin required as much food as an American or a European, you might wonder how he would ever get enough to eat in the desert. But if you can realize how little it really takes to keep him alive you will not wonder that he can live in the desert or anywhere. What do you imagine he eats through the day on a long desert journey? He takes a double handful of barley flour and mixes with it a little salt and water. Then he digs a hole in the sand, throws in a few sticks and dried vines, and lights a fire. When this small oven is heated, he takes out the fire and spreads his paste on the hot coals, leaving it there until it is thoroughly dry. Then he takes it out, knocks off the ashes, and eats it as his one meal for the twenty-four hours. And yet these men are strong, muscular, and powerfully built. Indeed, the Arab is one of the finest specimens of physical manhood found anywhere.

Meat is seldom eaten by the dwellers in the desert — only when the killing of an animal is done as a sacrifice. Then the blood is poured out on the ground as an offering to Allah, who gives life, and the flesh is eaten as an act of worship. A lamb or kid is sometimes killed and eaten in honor of a guest, or at some celebration, like a wedding.

Ewing Galloway

BUENOS AIRES

OUR NEIGHBORS IN SOUTH AMERICA

By Bernadine Bailey

You have no doubt heard or read the expression "the twenty-one American republics." Two of these republics, the United States and Mexico, are in North America. Six are in Central America. Three in the West Indies. And all the rest are in South America.

Although more than twice as large as the United States, South America has only about two-thirds as many people. Except in Brazil, where Portuguese is spoken, the people of South America speak Spanish. Racially the majority are "mestizos," which means a mixture of white and Indian blood, although there are also many pure whites and pure Indians. Some of the most cultured people are of part Indian ancestry and are proud of it.

ARGENTINA

Argentina is more like the United States than any other country in South America. It has more miles of railways, more foreign trade, more factories, and is in closer touch with the rest of the world than are the other countries. It exports large quantities of meat, hides, wool, linseed, corn and wheat.

Until the middle of the 19th century, the endless plains of Argentina were unfenced and the cattle roamed wild. Dwellings were fifteen to twenty miles apart. About 1850, the wild character of the country began to change. Wire fences were put up and the wealthy landowners began to keep their cattle on their own lands. The first refrigerator ship, which came to Argentina in 1876, completely changed conditions and made this country one of the chief sources of meat for the world. Today there are more than three times as many cattle as human beings in Argentina. By confining the cattle within fences, such crops as wheat, corn, and linseed can be raised and Argentina has become one of the world's great graneries. Packers from the United States and England have built plants there. Railroads have been built to bring the inland products to Buenos Aires; light

Ewing Galloway

GAUCHOS

and power companies are installed there; telephones and automobiles are in universal use. Through the help of foreign capital, Argentina has become one of the world's richest producers.

BUENOS AIRES, CITY OF GOOD BREEZES

Argentina's activities are centered in Buenos Aires, the City of Good Breezes. In the last two hundred years it has grown from a small town dependent on the smuggling trade to an important seaport city of two and a half million —a fifth of all the people in Argentina. Here live the wealthy men and women, here are art and music, and theatre and all modern luxuries. You might be surprised if you went to Buenos Aires in January and found summer weather, but then you would remember that in the southern hemisphere the seasons are the opposite of ours. Although the city looks much like any European or American city, there are some interesting, and even amusing, differences. For example, if you wanted a taxi, you would hiss for one.

You could hear wonderful concerts for as little as ten cents and there are movies everywhere. There is also a subway and an underground parking space for autos. The people of Buenos Aires wear the latest European styles and live in modern apartments with all the latest improvements. Many nationalities are found here, and it is a common thing to hear Italian, Russian, German, French, and English as you walk along the street. At busy intersections the policemen direct traffic from lofty, parasol-covered pedestals. In the center of the town there is a 207-foot tower with an enormous clock presented to Buenos Aires in 1916 by the British residents. You can buy peanuts from a roaster in the shape of a locomotive, or a singing canary from a vender who wheels his birds about on a tricycle, and even ice cream on a stick, called a "smak." In the zoo the children ride llamas instead of ponies. There is a huge beach, large enough to accommodate more than 15,000 bathers, but everyone must obey the life guard, for the wind has a way of shifting very suddenly and whipping up the breakers to dangerous heights, and bathers dare not venture far from the shore.

THE GAUCHOS

The most picturesque class of people in Argentina are the gauchos. These fearless and almost uncivilized cattle herders who roam the endless prairies, or pampas, know no law except that of force. A racial mixture of Spanish and Indian, the gaucho is a hard-riding, hard-hitting fellow. He wears broad-flowing trousers, called bombachos, thrust into high boots. His large slouch hat is usually faded, and he carries a blanket around his waist. He always has a short, stout leather whip fastened to his wrist and, for a weapon and tool, he carries a huge knife called a facon. With this facon he cuts his food—a leg of lamb or mutton, scorched and burned on the outside and left almost raw in the inside. Quite necessary, too, is his poncho, thrown over his left arm and used as a shield. The poncho is never thrown away as long as it will hold together, for the gaucho is proud of its many bullet holes and knife slashes. This treasured garment has a hole in it for his head, and the herdsman wears it over his shoulders when it rains. He has another garment called the chirapa, which is used to protect his legs. His huge, foot-wide belt, or tirador, protects his body from knife thrusts because of its width, and it also contains many pockets or bags, used as a sheath for his knife and holsters for his guns. A gaudy handkerchief around his

neck and a broad sombrero complete the gaucho's colorful costume. He is tall, handsome, and polite in a proud, wild way. Next to his skill in using his knife he is best at a dance—the tango, the gato, and the jota.

The gauchos live a free, hard life. They despise the city and care more for the ornaments of silver in the reins of their bridles and the trappings of their saddles than for the finest house. From childhood they are trained to be alert, vigorous horsemen and cattlemen, and wield the lariat with greatest skill. When traveling over the prairies they sleep in the open and live chiefly on the native drink, *maté*, which is brewed from herbs. When they return they are ready for a gay celebration. So a dance is held on the earthen floor of the kitchen. Usually it lasts until sunrise, with midnight refreshments of a hot stew of rice and mutton. Men and women eat separately, and each person has his own gourd for *maté*, which is sipped through a tube.

BRAZIL, LAND OF RICHES

Can you imagine a naked Indian attending opera in a marble opera house? Not so long ago this was no unusual sight in Brazil. Made up of twenty states, the United States of Brazil is the largest of the South American republics and the least populated in proportion to its size. It is also the richest in resources and at the same time the least developed. Brazil could easily become one of the world's greatest food-producing countries.

Ninety percent of the people of Brazil live along the eastern coast, where the land is high and the climate temperate the year around. Outside this narrow strip there are no telephones, no radio, no automobiles because there are no roads, and no trains because there are no rails for them to run on and no towns to connect. About 3,000,000 square miles of Brazil lie in the torrid zone, a primitive jungle inhabited by savages, snakes, and a great variety of tropical animals.

The Amazon, the largest river in the world, cuts through the northern part of Brazil and with its branches provides about 16,000 miles of navigable waterways through the rich, tropical jungle. This jungle was important in the early years of this century, when Brazil furnished the greater part of the world's supply of rubber and towns sprang up along the banks of the Amazon. But since the British and Dutch have turned to the East Indies for their supply of rubber the naked Indians no longer frequent the marble opera houses, which are rapidly being swallowed up in the jungle.

In the delta of the Amazon lies Marajo Island, twice as large as the state of Massachusetts, made up of a primitive tropical jungle and vast grazing grounds for cattle. The Indians who live there, practically on the equator, are ignorant, sturdy people who fish and raise cattle for a living. As horses are scarce, many of these cattlemen, called "vaqueros," ride oxen, or animals that are half oxen and half zebu. There are no mosquitoes in this delta island, but much more disagreeable are the fleas which torture both men and beasts. There are also bats which live on fish and insects; fierce, iron-jawed fish that attack the cattle when

Ewing Galloway

A BRAZILIAN INDIAN

RIO DE JANEIRO *Ewing Galloway*

they wade into the shallow water to drink; and crocodiles, or "Caymans," that destroy hundreds of cattle every year. There are troops of monkeys, great lizards, large-billed toucans, porcupines, and the kinkajou, or "honey bear" which lives high in the treetops and seldom comes down to the ground.

The high seaboard lands of Brazil are among the most fertile spots on earth and produce almost every crop known to man: coffee, corn, wheat, tea, cotton, rice, sugar, and all kinds of fruit. There are also grassy plains, as in Argentina, which can support large herds of cattle. Brazil's chief crop is coffee and about two-thirds of the world's supply is grown there on more than three billion coffee trees. Brazil is also rich in minerals, especially iron; and diamond mines are still producing beautiful gems although they have been worked for more than two hundred years.

RIO, THE WORLD'S MOST BEAUTIFUL CITY

Rio de Janeiro, the "River of January," is as gay and beautiful as a light opera. Life in the capital of Brazil seems to be one long carnival of dancing and song. Situated on a bay of tropical blue that is studded with green islands, Rio is world-famous for its beauty. Mountains and oddly shaped crags make a bizarre background, while ribbons of sandy beach make an alluring foreground for the city. There are many streets as wide as boulevards, and others so narrow that only pedestrians can enter them. Modern buildings, an opera house, a public library, and exclusive shops like those in New York or Paris help to make up a city of culture and intellect. Yet a few minutes' drive from the city brings one face to face with the jungle.

Rio de Janeiro has grown from a cluster of fishermen's huts, and an empty sandy beach where fishermen dried their nets, to a city of beauty and luxury in only fifty years. As in Paris, many of the cafes have tables on the street, where the strong, heavily sweetened coffee is drunk. The tall hotels and apartment houses, built along the silver sickle of beach, make Rio the Riviera of the Western Hemisphere.

Inherited from its ancestral Portugal is the custom of laying sidewalks of mosaic set in

spiral patterns and broken by designs indicating the various clubs and buildings. In front of the jockey club, for example, there is a mosaic of a horse's head. In front of the naval club is a mosaic of a fish. On the shore of the bay is an airport where the huge clipper planes come in from Miami or from Buenos Aires. High on a hill near the city is Penha Church, with its 365 stone steps, one for each day of the year. Worshippers formerly made this ascent on their knees, but this is no longer permitted. On the summit of another peak is a huge statue of Christ, lighted by floodlights in the evening.

Carnival time, which takes place three days before Ash Wednesday, is like the New Orleans Mardi Gras — a joyous occasion of fun, songs, costumes, dancing, noise, floats, and confetti. Among the half dozen languages which are common in Rio is a sort of slang jargon as picturesque as the city itself. In this jargon, a pawn shop is "Noah's Ark," a policeman is a "button," a patrol wagon is a "merry widow" or a "chicken coop," while the president is called the "Big Papa."

Ewing Galloway

CUZCO, ANCIENT CITY OF PERU

PERU, LAND OF THE INCAS

No country in the world has a richer, more colorful past than Peru. Here, on the high tablelands of the Andes, once flourished the wonderful Inca civilization. Sun worshippers, the Incas built their chief city high up in a fertile valley. Here they built houses of stone without the use of mortar, fitting the enormous slabs together so perfectly that even a penknife could not be inserted between them. The Incas built terraces on the mountains where crops could be cultivated. They stored up the water of the spring rains and used it later for irrigation. They built paved roads and suspension bridges. They were skilled weavers. They made pottery of exquisite design and color.

The Incas were musical and they made flutes of bone or cane, trumpets of clay, and bells of bronze and copper that gave out different tones. They used no writing, but kept their records by means of colored knotted cords. The study of the stars was an art in which they were deeply versed, and for computing seasons they used sundials. Groups of towers cast shadows which were used in determining the equinoxes and solstices. All the children over five years of age had some work to do. A gay, happy race, the Incas wore bright clothes and gorgeous jewelry.

This chapter of Peru's history was ended four hundred years ago, when the Spanish conquerors destroyed the great Inca Empire. For three hundred years the Spaniards forced the native Indians, or Incas, to work the gold mines. The Spaniards built palaces to live in, and made Lima, the capital of Peru, the most Spanish city of all South America. When the Spanish domination ended, the wealthy Peruvians continued to exploit the country for their own interests. As the demand for gold fell off, the rich deposits of guano (bird droppings — one of the finest of fertilizers) took its place as the chief export of Peru. Oil and copper also became of great industrial importance.

Directly behind the costal lowlands, the Andes rise to their greatest height, then sink to a wonderfully fertile valley which was highly cultivated by the Incas, but is now entirely

Ewing Galloway

LLAMAS IN FRONT OF THE DOMINICAN MONASTERY, CUZCO

neglected. Today the Peruvian government is building a road across the Andes which will connect this fertile region with Lima. Beyond the second range of mountains the country lies untouched in tropical richness, but almost entirely cut off from Lima. The only part of the country which is really valuable to the Peruvians is the narrow strip of coast where the wealthy white people live — scarcely ten percent of the entire population.

The llama is the Peruvian beast of burden. Its body is like that of a camel without a hump, but is much smaller. A full grown llama stands about three feet high at the shoulder. The Incas had several hundred thousand of these animals, which need very little food and can go several days without water. The males are used for transportation and the females for meat and milk. In general the llama is a docile beast, but if he thinks too great a burden has been put on his back, he will spit out a foul-smelling fluid. The alpaca, valued for its fine wool, is a species of llama.

CHILE

Chile is more than 2,000 miles long and nowhere more than a hundred miles wide, with the Andes as its eastern boundary. The northern part of Chile, though barren, is rich in coal and iron mines. At one time this part of Chile supplied nearly the whole world with nitrates, but since synthetic nitrates have come into use much of Chile's wealth has been wiped out. Many of the inhabitants of the mining region have drifted to the fertile middle section of this long, narrow country.

The great earthquake of 1939 was a greater disaster to the people of Chile than the loss of the nitrate trade, since it affected all those who

live in the rich fertile valley in the middle section of the country. This earthquake may in time bring about a redistribution of the ownership of land, since whole tracts were ruined.

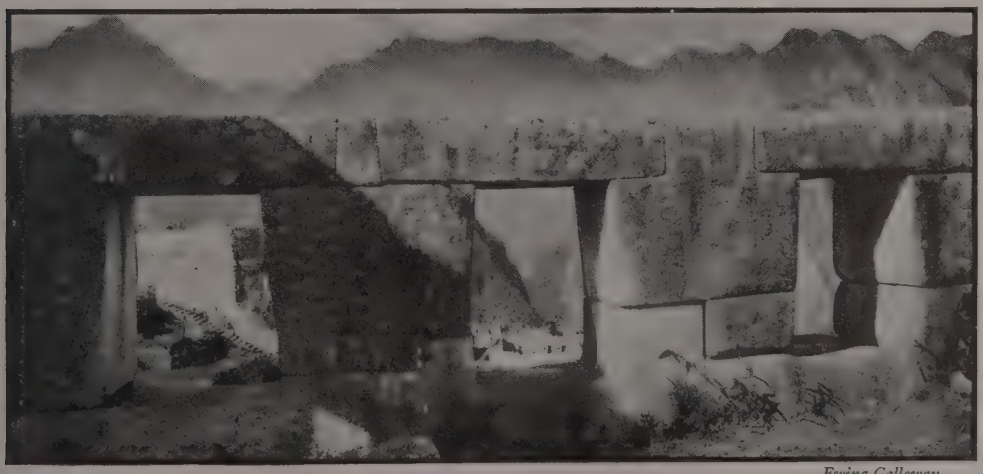
THE PATAGONIANS

A most interesting part of South America is that region known as Patagonia, at its southernmost tip. Patagonia, a rocky stretch of country ending in Cape Horn, is partly in Chile and partly in Argentina. But the Indians who live there are little troubled by boundaries, governments, or laws. "Might is right" is their only law, and the best man always wins.

The early Spanish explorers described these native Indians as giants, since most of them are well over six feet tall. The women had their heads shaved, while the men wore their hair down to their waists or longer, binding it with headbands into which they placed sticks used in making fires. Through holes bored in their lower lips, they thrust highly polished bone and wooden pegs. In order to withstand the cold fierce winds, they rubbed their bodies with melted fat mixed with chalk and sulphur, which closed the pores. Their only clothes were made of animal skins. In warm weather they discarded these skins and painted their bodies with juices and dyes from plants. Their chief food was meat, cut into large pieces and scorched in the fire and then torn apart with their teeth, even though the inside was almost raw.

The chief amusement of the Patagonians was dancing, for which they had a rhythmic rather than a melodic music. They shook rattles made from tree bark sewed together and containing little stones.

The present-day people of Patagonia are a mixture of Indian, Spanish, and Negro blood, and even today they are a fierce and little civilized race. Since they do not adapt themselves to civilized ways, they are gradually disappearing. A wandering race, they live in the rudest and most primitive manner, existing chiefly by hunting. Courageous in fighting, they are barbarous toward their enemies. The Patagonian dwellings are made of skins stitched together and stretched over wooden poles set in three rows. These skins are fastened to the ground with bone pegs. The dwelling is divided into the two main parts, and these again into smaller rooms. The Patagonians are very superstitious and are extremely afraid of death. They believe that by sleeping with their heads to the east they can prolong their lives. During the dreadful storms that frequently arise, they huddle together in terror and hide their heads in their hands. In the Patagonian area of Chile there are thousands of sheep to every person, and the chief products are wool and mutton.



Ewing Galloway

INCA RUINS HIGH IN THE PERUVIAN ANDES

A LAPLANDER AND HIS FAMILY AT HOME

LAPPS, THE SMALLEST PEOPLE IN EUROPE

IN northern Norway, Sweden, Finland and Russia, lying wholly in the Arctic zone, is a region that is called Lapland. The people who live there are called Laplanders, or Lapps. They used to be spoken of as dwarfs, but this is not quite correct, as they are about five feet tall. They are, however, the shortest people in Europe. One queer thing about them is that they have very short arms and legs and long bodies. They have the low forehead, high cheekbones, and flat features of the Mongolian race, to which they belong.

You can imagine the kind of clothing people would wear in a country that is always cold. In the winter the Lapps wear suits of reindeer skin with the hairy side turned in; in summer, woolen shirts and tight-fitting trousers of reindeer skin. The women are dressed in a single, long woolen garment; those who live near the shore or mingle with the northern Europeans wear undergarments and trim their dresses with bright colors.

The dwellings of the Lapps are very simple. Those who lead a wandering life dwell in tents made of coarse woolen cloth stretched over a frame of poles. Fortunately the cloth is loosely woven, and so allows a little ventilation, for in these tents the Lapps and their dogs all live together as one family. Those who are contented to stay in one place build huts of logs, often covered with earth and decorated with branches of trees. In appearance they are something like the igloos of the Eskimos.

The Lapps have a hard struggle to get their living in the dreary land in which they live, but they have great endurance, and are often happier and more contented in their simple life than many another class of people with greater luxuries. They hunt for wild animals, raise deer, and catch fish. The reindeer furnish them milk, from which they make quantities of cheese.

THE CHANGING CHINESE

CHINA is the country on the opposite side of the world from ourselves. We say "through to China" as the limit of the land we own. And in the same way many customs and ways of the people of this far-off land are exactly opposite to ours.

The Chinese are in some ways the oldest and in others the newest people in the world. Even today large numbers of the Chinese people look down on all foreigners as "Western barbarians," counting us as new and uncultured races. In this they are not without some right, for the civilization of China was old when our ancestors in Europe were rude barbarians. Yet, on the other hand, China has opened its doors to many of the ideas and methods of Western civilization and has accepted as its leaders men, like Generalissimo Chiang Kai-Shek, of most progressive views.

WHAT THEY ARE LIKE

The Chinese are members of the Mongol race. They are well built but rather short, with yellowish, dark complexion, coarse black hair, narrow, slanting black eyes, short, flat noses, and rather thick lips. The yellow man has a firmer hold on life than the white. He is wonderfully tough, and able to endure hardship and exposure and to withstand bad conditions more successfully than any of the Caucasian peoples. Poverty has compelled crowding and the use of bad food and living in foul air. The Chinese have met these conditions, and those who have lived to grow up under them have a surprising power to work. Patient, persevering industry is one of their most striking characteristics. Of this the Chinese farmer is the best example. China is an agricultural country. Everywhere the common people are landowners, but the plots of ground which they own and till are so tiny that to obtain the barest necessities of life they must practice what we in this country are calling "intensive farming." In the best regions every handful of earth has been almost literally passed through the hands of its cultivators, every leaf inspected, every inch watered and manured, watched and cared for, like a house garden. The result is a land fertile beyond comparison, and a cultivation of the soil that has permitted no waste places. All this farming, as everything else in the land, has been done in accordance with the ways of the past. Until recently the farming implements have been the same as those used five hundred or a thousand years ago, and even now the small farmers are slow to make changes. Disinclination to change is one of the instincts of the Chinese temperament.

It seems to us, who see the Chinese as foreigners in our streets, that they are very serious. They are naturally reserved and earnest, but at home they are bright and cheerful. They are forever laughing, playing tricks, making fun, and exchanging wit. Those who come to know them find them human and likable. Smile at them, and a smile comes back. Their quick temper leads to many family quarrels, which they take no pains to hide from the public. They are always polite and keen to acquire good manners and refined ways. Indeed, politeness is to them far more than a mere code of manners. It is a system handed down by tradition and so perfected as to be almost a religion. Confucius, their great teacher, said, "All virtues have their source in etiquette." There are ceremonials for every social relation, and rules for every possible occasion. Those who know the Chinese best, including foreigners who trade with them, give them a very high character for honesty and fair dealing, as well as for peaceableness and kindliness.

THEIR DRESS

Their dress has remained the same, generally speaking, for centuries. Garments of fur or velvet or silk are handed down from parent to child for two, three, or more generations, and there is no reproach attached to wearing a garment eighty or ninety years old. Clothes are largely made of cotton and silk, furs and skin being worn in winter. A finely dressed gentleman of the wealthy class might easily have on clothing costing fifteen hundred dollars. The costume consists of inner and outer tunics made of cotton or silk, sometimes short, sometimes reaching to the feet, and with wide sleeves extending below the hands and suitable as pockets. A Chinese man never "pockets" anything, as an American does. He actually "sleeves" it.

A CHINESE FAMILY OF MEANS IN THE HOME COURTYARD

The dress is completed by loose trousers covered to the knee with cloth stockings, tight leggings being pulled over both in winter. Quilted cotton garments are very common, and so made as to protect the whole person from cold and obviate the need of fires.

The women are described as the most completely and modestly dressed of any women in the world. Their two garments cover them without interfering with their ease in movement, and their girls work and play as freely as boys.

ODD CUSTOMS OF THE PAST

For centuries Chinese wore their hair long and bound upon the top of the head. But two and a half centuries ago the Manchu Tartars invaded China from the north, conquered it, and elected their chief emperor. The Manchus, who wore their hair in a queue, or "long tail," forced their Chinese subjects to adopt this style of hairdressing, and a long, thick queue was, until the recent edict, a point of pride with every honest Chinese. Long nails were fashionable, especially among the educated classes, and often necessitated nail protectors. Of course one could hardly do much work with long nails.

Perhaps the queerest custom among the Chinese was that of foot-binding. Young girls of the better classes had their feet bound tightly in early infancy, the four small toes being tucked under the sole, of which after a time they became a part. When the painful process was complete, the Chinese lady had what has been considered a mark of great beauty and elegance, — a queer, deformed little foot which would fit into a shoe three and a half inches long. The Chinese lady did not walk; she tottered or hopped. But then it was not considered good form for her to go on foot very much. She was usually carried about in a sedan chair. The younger generation of Chinese who have helped to establish the republic are doing away with this foolish and cruel habit of foot-binding. The Manchus, the conquerors of China, never practiced it, and it was not allowed in the

palace. The educated Chinese girl of to-day would no more consider it than would her Western sister. But the custom persisted for nearly a thousand years, and is one of the causes of the present conditions in China.

In dress and custom, as in everything else, it must be remembered that the tide has turned in China. Tradition is no longer the supreme law. Within the last few years one custom after another has been done away with or changed among the more educated and advanced classes. In the first constitutional convention, in 1912, nearly all the men were in European dress. All through China there is a new consciousness of progress, and an eager desire to know how to do things in the best way. The officers of the new republic have most of them been taught in America, England, and Europe and are modern in their ideas. (You will read more of their adoption of new ways in Volume VII.) Yet wisely they build on the foundations of the past, such as the old Chinese reverence for the family.

THE IMPORTANCE OF THE FAMILY

The whole political and social organization of the nation rested on the family. The supreme duty of a child was toward his parents. Both Confucius and wise men before him taught that reverence for parents was the greatest virtue that could be practiced. The Chinese have carried this to the extreme of worshiping their dead ancestors. In every house stands a wooden cabinet containing slips of wood called "ancestral tablets," because the Chinese think that the souls of their ancestors live in them. Each one has writing upon it, telling the name of the person whose soul is said to be inside.

Fear mixes with the worship of the dead at every turn. When people are sick or lose money or have some other trouble, they think that perhaps the spirits in the tablets are angry and are bringing evil upon their home. They may offer food, and burn paper to represent money, servants, and horses to please them,

THE GREAT WALL OF CHINA *Ewing Galloway*

This ancient wall, built sixteen hundred years ago to protect China from invasion from the north, is fifteen hundred miles long. For most of the distance it is twenty feet high and twenty feet wide at the top.

thinking that when burnt these things pass into the spirit land, where their relatives enjoy them.

This respect of young people for the past has a beautiful side. The rights of parents are such that every man with grandsons has what is as sure as an old-age pension. Disrespect to his elders would be undreamed of by the Chinese boy.

EDUCATION

In 1905 a wonderful step in educational reform was taken when the empire started an entirely new system of schools, based on European methods. China could not help seeing that her little neighbor, Japan, although an Asiatic nation like herself, was rapidly becoming a great figure in the councils of the world through her adoption of Western modes of education; and Chinese students who had been sent abroad to study were bringing back new and revolutionary ideas. Missionary schools were also teaching the new learning.

The Chinese have a great reverence for written language. Waste printed paper is collected from house to house and burned, to preserve it from profanation. The Chinese writing is a kind of picture writing. It does not represent the sound of the spoken words, but gives a kind of picture, or rather symbol, of the idea or thing to be expressed. The number of these words is reckoned at fifty thousand. One of the most striking changes recently made in China is the adoption of an alphabet almost like ours, in place of the present symbols. This phonetic alphabet is being widely taught in schools, colleges, and even village assemblies, and is proving a great success.

The Chinese are a great people, great in numbers and in promise for the future. No other nation has been so true to itself and "preserved its type so unaltered." No nation has developed a civilization so completely its own and independent of outside influence. It has held to its own ideas and preserved its own literature. The secret of this wonderful self-preservation is its constant study of and reverence for the past. Even the Japanese, who have made war against the Chinese as part of the Japanese plan of expansion, admit that the Chinese national spirit is unconquerable.

THE JAPANESE

LOOK on your map of Asia and you will notice a group of narrow islands lying in a chain off the coast of China, from which they are separated by the Japan Sea. These comprise the ancient island empire of Japan, a little country, but the home of a remarkable race which in less than a century has greatly changed its mode of life through the adoption of Western customs and manners. The name "Japan" is from Cipangu, a European misspelling of Chi-pen-kue, which is the Chinese name for the country. Marco Polo brought back the first knowledge of this region to Europe in 1295, and with it this name by which the islands were known to their Chinese neighbors. By its own people Japan is called Nippon, an ancient name meaning "Land of the Rising Sun," or oftener Dai Nippon, "Great Land of the Rising Sun."

Up to 1854 Japan was a very separate little Oriental country, cut off by its laws and customs from all the rest of the world. But when Commodore Perry sailed into the harbor of Yokohama one memorable day with a fleet of United States war vessels, he was granted a treaty opening their ports to the Western world. Today they unite the East and the West in their life. Go to Japan and you will find the telephone, steam and electric cars, houses heated by steam, public schools, and many other marks of a modern progressive nation. But the old customs which make the Japanese so interesting still continue; and thus we find in them a strange blending of the old and the new.

The Japanese are short in stature, with yellowish-brown skin, prominent cheekbones, slightly oblique eyes, and straight black hair. They are highly intelligent and quick-witted, and, more than any other Asiatics, have shown the ability to adapt to their own use the inventions and machinery of Western civilization. Although quick-tempered and sensitive in small matters, they are an extremely courteous people. From babyhood they are all taught to be most gentle and polite. To be rude or to talk loud is considered a serious fault.

There is a great deal of real home life among the Japanese. Family ties are very strong. Children are always in the care of their mothers

and are seldom given to the care of servants. So, as a child grows older, it shares all the hopes and interests of its parents. Obedience to parents is a very strict law.

A LAND OF FASCINATING SIGHTS

The Japanese, with their industry and wonderful artistic taste, have turned their country into a beautifully kept garden. And what a flowery kingdom Nature has given them! Chrysanthemums, irises, peonies, cherry and plum blossoms in their season, make the fields visions of loveliness; and with the many shrines and temples scattered throughout the land, what wonder that it presents a fascinating picture to foreigners?

To the stranger everything in Japan appears quaint and curious, almost elfish. As you glance down a city street you see blue everywhere; houses have blue roofs; shop fronts are hung with blue; the people have more blue in their costumes than any other color. The shops are low and light, with their first stories open to the street, and there is an endless flutter of flags and dark blue drapery. The floors of the tiny shops are well raised above the level of the street and covered with matting. The dark blue blouses of the laboring men are adorned on the back with curious letters, a sort of trademark, making known the name of some guild or company of which the wearer is a member.

Children are everywhere, the funny Japanese babies being carried in hoods on the backs of their sisters or cunning little mothers. One may see two demure Japanese ladies under a gay paper sunshade, their sleek black hair beautifully dressed, taking an airing in a jinrikisha. Do you know what a jinrikisha is? It is a little carriage or cart, for all the world like a chair on two wheels, and it is drawn by a man, who grasps it by its two handles. You can hire a jinrikisha man for the whole day, and he will trot through the streets with you on his straw shoes without seeming to tire himself very much. He can go into small places, where carriages cannot go, and he does not try to run away with you! But now automobiles are pushing him off many of the main, crowded thoroughfares of the cities.

HOW THE JAPANESE DRESS

The Japanese native costume has been unchanged for hundreds of years, and is practically the same for men and women. All who can afford it have the *bitomo*, or undergarment of bright silk. Over this are worn two or three

A JAPANESE JUDGE

and sometimes five or six flowing robes — *kimonos* — of silk or crêpe. About the waist is worn the *obi*, a wide girdle of satin or heavy silk, tied in a large square bow behind. On the feet are high clods of elm wood or straw sandals, according to the weather. Umbrellas and fans are used by both sexes. The little children are dressed the same as their big brothers and sisters, but in brighter colors. White, instead of black, is the mourning color. For business convenience, many of the Japanese men now wear the European dress, but in their own homes they are likely to put on the native costume.

HOUSES [1]

Homes in Japan are of the simplest construction possible. Doors and passages are found only in a very few houses, the rooms being divided by sliding paper panels. These can be manipulated at will and the entire dwelling can be made into a single large room if the necessity arises. Containers holding smoking charcoal and ornamental stands for the display of flowers, constitute the furniture. The well-to-do Japanese have a larger supply of furniture, but these are exhibited only when the occasion arises.

The exterior of the Japanese home is a model of beauty and simplicity. Tiny little gardens, often bordering a small pond, add to the charm of the scene. And it is not uncommon to see a tiny island, with a pretty little arched bridge of wood, in the center of the pond. Gardens are found almost everywhere, testifying to the appeal which nature has for the Japanese. They revel in gayly colored flowers. The most common of these are the plum blossom, cherry blossom, and the purple iris. The blossoming of rows of cherry trees is an unforgettable sight to travelers in Japan.

CITIES

Tokio, the capital, with a population of over five million, is one of the largest cities in the world. Its importance has considerably increased with the advent of new ideas from the occident and the introduction of industrialism into Japan. Edifices of steel and concrete are taking the place of less substantial Japanese dwellings. The city was formerly called Yedo; it assumed the name of Tokio in 1868, when the Mikado took up his abode there. Probably the outstanding building of Tokio, and of all Japan, is the Imperial Palace.

Kyoto is the art center of Japan. Bronze, porcelain, silks, and embroideries made here find an eager demand throughout the world. Picturesque temples add to the quaintness of this old and interesting city. Osaka is one of the leading industrial communities. Its factories stretch in all directions.

RELIGION

Japanese have been allowed absolute freedom of religious belief since 1889. Shinto is the old native faith. It is, for the most part, a reverence for spirits and the imperial house. Hero worship forms an integral part of this primitive religion.

Buddhism is one of the most prominent religions in Japan. It entered Japan by way of China much as it had entered China from India, the home of its founder. Buddhist temples are found in all parts of Japan. There are now more than seventy sects.

Christianity, while still retaining a large membership, is handicapped by the scorn placed on it when it was decreed to be abolished in the seventeenth century. It is gaining, however, a strong place in Japanese life.

EDUCATION

Since 1871 Japan has given a great deal of attention to education. For the most part the public system is not unlike that of the United States. However, Germany is also a source of new educational ideas. Many Japanese students are to be found both in Europe and in America.

There are four phases in the educational system of Japan:

1. The kindergarten or the school for very young children. The average child found here is from three to six years of age.

2. Elementary schools for students between the ages of six to ten.

3. Middle schools. The subject matter taught at this stage contains physics, chemistry, geology, philosophy, and other advanced subjects.

4. The University. This is the highest educational institution in Japan. There are six imperial Universities scattered throughout the nation.

From this brief account you know something of the people of Japan and their customs. (You will find out more about Japan as a nation, and its political and industrial life, in Volume VII, pages 305–308.)

[1] This page is adapted from "Nations of Our New World," by Hatch and Stull, Allyn and Bacon, publishers.

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A JAPANESE FAMILY AT HOME

These are typical faces, and the scene is characteristic throughout. Fishing from the home piazza makes sport convenient. The dainty dress is something to be not only admired but imitated. The Japanese love the country and simple life. As the picture shows, the houses are built very light, and seem frail.

A HINDU FAMILY OF THE SUDRA OR PEASANT CASTE

PEOPLE OF INDIA

THE Hindus are the chief people of India, that great region of southern Asia whose northern boundary is the range of the Himalaya Mountains. The Hindus proper are of Caucasic stock, as is seen by their straight noses and perfectly regular features. They are a dark-skinned people, and often very handsome. Besides these there are two other races in India, Negroes and Mongolians. The civilized Caucasic Hindus, or Aryans, entered India from the north many centuries ago, conquered the black natives, and drove them into the hills.

These Aryan conquerors looked with hatred and scorn on the blacks, and strictly forbade marriage with them. This was the origin of the famous caste system of India, which arose as a matter of color. The blacks were more numerous than their fair Aryan conquerors and would doubtless have absorbed them but for the system of caste. As now known in India, caste is dependent on race, occupation, and religion. The four original castes are: (1) the priests or Brahmans; (2) the warriors; (3) citizens, traders, and agriculturists; (4) the menials or low-grade laborers (sudras). There are of course a great many subdivisions of these four great classes. People of one caste are not allowed to marry into another caste. In some parts of India those who belong to different castes are as far apart from each other as if the lower-caste men were not human beings at all, and a high-caste man will not touch a low-caste one even to save his life. There is also an unfortunate class of people called pariahs, or outcasts, who live on the outskirts of civilization. The term originally meant "hill men."

THE RELIGION OF INDIA

The sacred scriptures of the Hindus are called the Vedas, and they were composed by the early Aryans on their conquering march through the country. A Hindu believes that everything we do in this life is punished or rewarded in another life on earth, and that everything that happens to him in this life is the result of something he has done in a previous life which he has forgotten. He fears very much to do wrong because he may suffer for it in his next life, or he may be born a cow or a frog or some other animal. Because of this, and because the spirits of his gods may be in trees or in animals or stones, he is very kind to animals and he worships trees and stones. The round of birth or death is very long, for the full number of lives is eight million four hundred thousand, and if, after the soul has made many steps upward, it breaks a rule of life, it may have to

BRAHMAN FAMILY, THE HIGHEST CASTE IN INDIA

go away back to the beginning. The one great hope is that sometime in the dim future, by keeping all the rules in one life after another, the spirit may be set free from birth and death.

When the hymns of the Vedas were composed, as now known, caste had not been thought of. Great chieftains chose learned men to officiate at religious services. As writing was unknown, those families who learned the hymns by heart became hereditary owners of them, and they proved to be a valuable family property. The powerful prayer was called Brahma, and the man who offered it Brahman. Thus the Brahman or priestly caste grew up. They had the learning and culture, as well as religion, and became the councilors of princes and teachers of the people, forming the highest and most powerful caste in India. They were treated almost as if they were gods, and many of them lived by the gifts of the people. They gradually became a class apart because of a distinct mode of living. They learned the sacred scriptures and tended the sacred fire. After marrying and bringing up a family, the Brahman retired to the forest and lived in solitude in the performance of religious rites. Finally, as an old man, he became still more separate from the world, such a man as is described by Kipling in "Kim." The Brahmans are an ancient caste, and are said to have been living in much the same fashion since the sixth century before Christ. They still have their colleges and devout students.

FAKIRS

Perhaps the queerest people in India are the fakirs. They wander about from city to city

and from temple to temple, and live on the gifts of the devout. The fakir covers his body with mud and ashes and makes his hair stick out in all sorts of uncouth forms with gum and clay. He has a boy whom he calls his "Chela" with him, and a brass bowl, and nothing else. The boy goes out with the bowl at breakfast time and begs till it is full; then he comes back to the fakir, where he is resting by the temple steps or by the wayside, to eat the meal with him.

Among the fakirs are men who do wonderful conjuring tricks. Sometimes a fakir will suddenly appear to climb up into the air, going hand over hand on a rope that is not there, till he vanishes into the sky. In a few minutes he will come quietly along the street as if nothing had happened. Sometimes he will take a mango fruit, open it and lift out the seeds, which he drops into a little tub of earth. As the bystanders watch they see a mango tree grow up and bear fruit before their eyes. Nobody can explain just how the fakir performs these weird tricks.

BUDDHA AND MOHAMMED

Although Brahmanism is the religion of over two hundred millions of the three hundred millions of India, about sixty millions are Mohammedans. Mohammedanism was founded by Mohammed, an Arabian prophet born at Mecca in the sixth century after Christ. He declared that there was only one God, whom he called "Allah," and that he himself was his prophet. Within fifty years of his death his followers had marched through the wild passes of the mountains into India. Since then there have been followers of the prophet there, and they have exercised a strong influence upon the Brahmans. Buddha, the greatest religious leader of India, sought to reform the idolatries and evils of Brahmanism, and while he did not make much impression upon the Hindus of India proper, in Burma he established Buddhism firmly, and from there it spread into China and Japan.

STRANGE CUSTOMS OF THE HINDUS

In another part of this book you read about the Ganges, the sacred river of the Hindus. There is a legend that the Princess Ganga, one of their goddesses, turned herself into this great river many, many years ago, that she might enrich and purify the country. Because of the sacredness of the Ganges men bathe in it and pray to die beside it; and they hope that after their bodies have been burned on its banks the ashes may be scattered over its waters and allowed to float away far out to sea.

Every bend of the Ganges is sacred. Pilgrims walk from its mouth to its source and back again, taking six months for the pilgrimage. If they wish to win more merit they lay themselves down on the ground and cover miles of the bank with their bodies instead of with their feet, and that takes them far longer. Fanatics used also to roll on the ground before the temples when a procession bearing idols was passing, or throw themselves under the Car of Juggernaut, and be killed amid applause, but this is now forbidden by law, as is the burning of widows and throwing of babies into the Ganges.

The most sacred city is Benares, and all the year long its streets and temples and river banks are thronged with pilgrims. They bathe and throw sandalwood, sweets, and flowers into the river.

To know more of the life of the people of India, read "Kim" by Rudyard Kipling, the fascinating story of a boy who wandered up and down India as the "chela" of a holy man. The political story of India is told in Volume VII, in the chapter "India Becomes An English Possession," page 128, while the children are described on pages 342–352. But the new life of India is best pictured in the story of Gandhi, in the following section. By his life and work as a spiritual leader he has done more to help the people of India than any other man of his time.

THREE LEADERS OF THEIR PEOPLE

THE YOUNG PATRIOT — JOSÉ RIZAL [1]

(By Frank C. Laubach)

PACIANO saw his eleven-year-old brother José hurrying toward him excitedly.

"Mother has been arrested," gasped José into the ear of Paciano.

"Arrested! What for?"

"They accused her of conspiring to kill Mrs. Ralondo. Mother, who would n't kill a fly! I know the real reason. It was that Spanish lieutenant whom father told to stop tramping on our rice fields. The brute took vengeance on mother — on a woman! What can we do, Paciano?"

"Nothing, José; we are too young. Come away; that guard is watching us."

This was José Rizal's first day in Manila. He had come from Calamba, forty miles south of Manila, to go to school with his older brother.

A week passed. One night Paciano rushed into their room, livid and trembling.

"What is it?" cried José. "What has happened to mother?"

"Convicted. And they have thrown her into prison."

An hour later José thrust a paper under Paciano's nose. "I can do something. This is the composition I was to write for to-morrow. Read it!"

Paciano read a fiery indictment of Spanish rule, culminating with an account of their mother's imprisonment.

"Tear it up quickly! It would be enough to send mother to the *garrote*. Tear it up. But, José, the composition is tremendous! You have talent, brother, and you must get ready for the day when you can save our country."

José crushed his composition in his hands and burned it. He must wait — and prepare. He would learn all that his professors knew and more. He would save his mother and all the other fathers and mothers who had been sent to prison or to some lonely distant exile.

He subjected himself to severe discipline of body and mind. As regularly as the clock he took daily exercise, walking, running, fencing, riding horseback. He refused to smoke or drink wine or stay up late at night. His nerve became cool and steady. Like Theodore Roosevelt, he built health out of frailty, and from that year he was never seriously ill in his life. Several hours each day he spent reading, always the best he could find in Spanish or Tagalog or Latin literature. He wasted no time, for he had set himself to a task which would tax his highest powers.

Soon he began to capture the school prizes. Other boys thought José had superior talents, but the real difference was that he had a purpose and made every hour of the day count. Two years he toiled and planned while his mother lay in prison. Then she was released for a reasón as shallow as the one which caused her imprisonment.

The governor general was visiting Calamba and saw José's little sister dance. He pulled her to his knee and said, "Pretty little lady, I never saw such dancing. Let me make you a present. What shall it be?"

"Give me my mother from prison," instantly said the girl.

"Who is this girl's mother? Set her free, whoever she is," commanded the governor general.

Two years in prison and out because of a dance! Hundreds of fathers and mothers and children were victims of brutality like this. More clearly than ever, José saw his life work. It was his motherland that lay sad, crushed, waiting to be freed from wrong, needing him.

At eighteen he wrote a poem, "To the Philippine Youth," which won first prize in the Manila Lyceum of Arts and Literature. The first stanza ran:

> Hold high the brow serene,
> O youth, where now you stand!
> Let the bright sheen of your grace be seen,
> Fair hope of my motherland!

That last line set Spanish officials muttering. Who ever before dared to speak here of any motherland except Spain? This insolent young Rizal would bear watching!

Then the students of the Ateneo de Manila put on a play called "Beside the Pasig." One character in the play was the devil, who denounced Spain for her cruelty. Spain so bad

[1] From "Seven Thousand Emeralds," Friendship Press, New York, N. Y. By permission of the publishers.

that even the devil condemns her! Who had dared to write that play? Who was the traitor? José Rizal. Ah, again!

Men had died for less than he had done. The Philippines were no longer safe for him. His brother and uncle gave him money; his sister gave him her diamond ring. Passage and a passport for leaving the country were secured for him by his cousin. Using this cousin's name, José slipped on the boat at midnight and sailed for Spain, where he was safe. For Spain was a hundred times freer than her colonies.

When José Rizal reached Madrid he at once plunged into preparation for his life task. He chose to become an oculist, since so many of his people suffered from diseases of the eye, and particularly because his own mother was beginning to lose her sight. In addition to medicine he studied literature, philosophy, French, German, and English.

Three books had more influence upon this young man than any others. First there was "Travels in the Philippines," by a German named Jagor. The book declared that the Filipinos had great ability but never had been given a chance. But what caught the eager eye of Rizal was what Jagor said of the United States. He said this country had set all South America afire with democratic ideals, and would some day send its influences across the Pacific. "The captivating magic power that the great republic exercises . . . will not fail to make itself felt also in the Philippines."

The second book was "Lives of the Presidents of the United States." Rizal read the book over and over until he wore it out, and then bought a new edition. How wonderful it was that men like Lincoln, born in poverty and in log cabins, had been able to make their way to the presidency!

The third book was "Uncle Tom's Cabin." When Rizal saw how this book had helped set the Negro slaves in the United States free, he conceived the idea of writing a book which would tell the story of the Philippines and of his own life.

Upon completing his course in medicine he went to Paris to practice with a famous eye specialist. After office hours each night he wrote chapter after chapter of his book. In two years it was ready. He gave it a strange title, "Noli Me Tangeri," which is the Latin for "touch me not." He had dared to tell a story nobody else had ever dared to tell. Ibarra, a desperate revolutionist, was clearly Rizal himself. Ibarra's father, who was imprisoned, was clearly Rizal's mother. Indeed, every character was recognized by the people of Calamba, his home town, the moment they saw the book. William Dean Howells, the famous American writer and critic, declared that "Noli Me Tangeri" was the best book that had been written in any language for fifty years.

José sent several boxes of the first edition from Europe to Manila disguised as merchandise. It was an instant success. People read it by lamplight and passed it on to their neighbors. Spies soon secured copies and took them to the government officials, and the Spanish friars for the first time saw themselves held up to ridicule. What made the book more dangerous was the fact that every word was stingingly, pitilessly true. "It is history written like fiction," said all who read it.

The government issued a decree that any Filipino found with the book in his possession was to be exiled, and his land confiscated and given to the one who had betrayed him. This did not stop people from reading the book, it only advertised it. José Rizal became the most famous man in the Philippines.

Meanwhile José's mother was going blind. José felt sure he could remove the cataracts which had grown over her eyes, and he dared to come home. With perfect success he performed the delicate operation for the first time in Philippine history. The report spread that he had performed a miracle. Patients came to him from all parts of the Philippines and even from China and Japan. Six months of busy popularity, and then the governor general advised him to leave the Islands, since, as the governor alleged, there were rumors that Rizal's life was threatened. The advice was really a command, so Rizal departed.

As he sailed across the Pacific Ocean his fellow passengers were astonished to hear him speaking to each passenger in that man's native tongue.

"How many languages do you know, Dr. Rizal?" asked a group of admirers seated about him one day on the deck.

"Let's count them," answered Rizal: "Tagalog, Spanish, Latin, Greek, French, German, English, Arab, Sanskrit, Hebrew, Swedish, Dutch, Catalan, Italian, Chinese, Japanese, Portuguese, Russian; is that seventeen or eighteen? Well, those are all I use with any facility."

He was fascinated as his train rolled across America. "Here," he exclaimed in his notes, "is the ideal land for men who are willing to work." But his visit to America was cut short by new troubles, for the Spanish friars, who had wanted him killed and not exiled, now took vengeance upon his relatives. They dug up the bones of his brother-in-law and "threw them out to the dogs." They had his brother Paciano banished to Mindoro, and his sisters arrested. The friars who owned, or claimed to own, the land occupied by Rizal's father, raised the rent until the old man appealed to the court — a fatal mistake for any Filipino to make in those days. Suddenly a company of soldiers appeared in Calamba and ordered the Rizal family to remove all buildings from the land in twenty-four hours. That was humanly impossible. The next day the soldiers set fire to house and barns. The governor who ordered this was General Weyler, who later, in Cuba, was called "Butcher Weyler."

José Rizal hurried to Madrid and tried to persuade the Spanish government to stop the oppression by Weyler and the friars. He failed. Bitterly he wrote a book called "El Filibusterismo." There is little humor in this book, "hot as metal — scorching whatever it touches." It ends with these words: "Where are the youth who will pour out their blood to wash away so much shame, so much crime, so much abomination? We await you, O youth! Come, for we await you!"

Rizal determined to risk his own life. He went to Borneo, where he secured from the British government a beautiful piece of land. Here he meant to bring his relatives and start a Filipino colony. Then he went to Hong Kong. From there he wrote two letters. "To be opened after my death," said the envelopes. The first was addressed, "The Filipinos." "I cannot live," it said, "and see so many persons suffer injustice on my account. . . . What matters death if one dies for what one loves, for native land and those one holds dear." The other was a pathetic letter to "Parents, brothers and sisters." He left these letters with a friend in Hong Kong, and set sail for Manila. The Spanish consul cabled to the Spanish governor in Manila, "The victim is in the trap."

Rizal was allowed to enter the Philippines. He went at once to the governor general and asked permission to take his relatives to Borneo. The governor refused. Rizal called together his friends and organized a Philippine League, to spread education and to improve the condition of the poor. The membership grew with amazing rapidity.

Suddenly the enemies of Rizal struck. The victim was thrown into prison, and a few days later was sailing to Mindanao as an exile under guard. The spot on the island, Dapitan, where he made his little home, is now a public park. It reveals what a paradise he and the Dapitan boys who adored him made of the place. They built a water supply for the town by bringing the water several miles from a mountain stream. Rizal purchased the latest farm implements from America and showed the farmers how to use them. He showed the fishermen how to make better nets. They thought him almost a god, and helped him gather rare specimens of shells, bugs, and flowers, which he sent to the museums of Europe. Here, too, he found time to express his beautiful soul in sculpture and painting. Art was as natural to him as breathing; it is to many Filipino youths. People came to him for medical treatment from all parts of the Far East, for he was reputed to be the best oculist in Asia. Instead of an exile he became a king of his realm, and he had a way of turning every spot he touched into a heaven, even when he was in prison.

Four years he blessed Dapitan by his exile there. Then he read that yellow fever was raging in Cuba, and asked permission to meet this call of need. Permission was granted, and he was half way to Cuba on a Spanish ship when something took place which sealed his fate. A revolution broke out in the Philippines, and though Rizal had nothing to do with the revolution, a cable was sent to the captain of the ship ordering his arrest. He was thrown into chains and taken to Manila.

The friars scoured the Islands for evidence against him. They tortured his brother Paciano

by having a screw turned into the palm of his left hand while a pen was put into his right hand to make him sign an accusation against José. He would not sign. Then he was hung up by his thumbs until he was insensible, and carted home.

José Rizal was brought before a court martial with his arms tied behind his back until they nearly touched. After a brief trial he was condemned. The sentence was pronounced — he was to be shot in twenty-four hours.

When his mother and sister Trinidad came to say farewell, José asked permission from the guard of the prison to bequeath his little lamp to his sister. As she took the lamp he said in English, so that the guard could not understand, "There is something inside."

Trinidad and her mother hurried home, pushed a little ball of paper out of the lamp, opened it, and read José Rizal's "Last Farewell." It is one of the noblest poems in any language. Every educated boy and girl in the Philippines now knows it in Spanish. Translation sadly spoils its music, yet we should know what he was saying:

Farewell, adored, sun-wooed motherland,
Thou pearl of Orient seas, our Eden lost.
I lay my sad, crushed life within thy hand;
And were life sweeter, full of promise grand,
Yet for thy ransom would I pay this cost.

I die — yet see, the skies glow overhead
Announcing dawn at last beyond the night;
And should you need to stain the dawn with red,
Behold my blood is for this purpose shed —
To dye incarnadine thy natal light.

E'er yet my childhood changed to youth I dreamed,
As youth will dream when vigor courses strong,
One day to see my Orient jewel redeemed,
Her dark eyes dried, her brow no longer seamed,
Her face uplifted, smiling, freed from wrong.

Sweet vision! Living hope! Undying fire!
"God-speed!" this soul cries out that soon must die;
"God-speed!" Oh, just to fall and lift thee higher,
To breathe new life in thee as I expire,
And then in thy charmed arms forever lie!

Land I adore, whose sadness makes me grieve;
Dear Philippines, my last farewell again!
With thee, my kindred, friends, and all I leave,
To go where none are slaves, where none deceive,
Where faith kills not, and God alone doth reign.

At daybreak Rizal, only thirty-six years of age, was led out to Bagumbayan field to be shot, where so many thousands, as innocent as he, had been shot or garrotted before.

A military doctor stepped from the lines and said, "May I feel your pulse, colleague?" The pulse was scarcely above normal. Amazed, the doctor said, "You are well, perfectly well," and stepped back.

Turning to the captain, Rizal asked, "Will you shoot me from the front, please?" Shooting in the back would signify that he was being executed as a traitor.

"I have orders to shoot you in the back."

"But I never was a traitor to my country or to Spain."

"My duty is to obey orders."

"Very well," said Rizal, and to the priest standing beside him, "Father, I forgive every man from the bottom of my heart."

He twisted his hand, bound behind him, to indicate the spot in his back where he wished them to aim. Eight soldiers fired together. With one last effort of will, José Rizal twisted his body about, to fall face upward.

A great monument stands on that spot now, the greatest monument in the Philippines. You may see the handsome young face of Rizal on a pedestal in every town and city of the Islands, but this mighty monument on Bagumbayan field, now called the Luneta, is the national shrine.

Rizal was executed on the morning of December 30, 1896. All the Islands burst into revolt that same day. Filipinos by the thousands slipped from the city to join the revolution. Among the revolutionists was Paciano, brother of the martyr. The Spanish friars had struck once too often. Now they fled into Manila for their lives, leaving a thousand churches without priests.

Rizal had said:

> I die — yet see, the skies glow overhead
> Announcing day at last beyond the night.

Eighteen months later this dream began to come true. While the conflict still raged, battleships from the United States silently stole into Manila Bay by night, and next morning sank the Spanish fleet.

Americans and Filipinos became allies; and, as Rizal had dreamed, the magic power of democratic ideals began to send its influence across the Pacific, through the Philippines, to all Asia.

SUN YAT-SEN

IF you were in one of the Nationalist cities of China on March twelfth, you would find all the streets decorated in blue and white and thronged with holiday makers. Even your ricksha would have a little white flag on which were picturesque Chinese characters in blue. The shop windows would have pictures and banners. In one you might see a picture of an open boat loaded with passengers labelled "The People of China," being pulled across a rough sea by a crew of sailors in blue and white. They steer for the shore by the light of three bright rays from a lighthouse on which are the words "The Three Principles of Sun Yat-sen." There would be pictures of Sun Yat-sen in every window, for March twelfth is the anniversary of the death of this great Chinese leader in the year 1925. Every patriot will be stopping, as he does every day in the year, to bow three times before his picture whenever he comes upon it.

The name of Sun Yat-sen first became known to the English-speaking world when in 1896 the newspapers featured an amazing story of how a Chinese refugee in England had been kidnapped, hidden, and held prisoner in the Chinese embassy in London, with the intention of deporting him secretly back to China where he would probably meet imprisonment or death. That story passed, as sensational stories do, and the next headlines about Sun Yat-sen were fifteen years later when he was proclaimed the First President of the newly established Chinese Republic. Before, between, and after those dates of 1896 and 1911 lay the story of an amazing career.

Sun Yat-sen was a Cantonese, born in 1866 in a small village between the city of Canton and the Portuguese colony of Macao, about thirty miles south of Hong Kong. His father was a Christian convert, and the boy came early under Western influence, both in his home and later in the high school at Honolulu in Hawaii, from which he graduated at the age of eighteen. Returning to China he became the first Chinese graduate of a British medical college at Hong Kong. He began the practice of medicine in Macao and was a successful surgeon and teacher when he came to know of the Young China party, which was seeking to free China from Manchu rule. For more than two hundred and fifty years the Manchus had ruled the empire. Now their officials were appointed with little regard to ability or character; their government was politically corrupt; and they considered all Westerners barbarians and were opposed to their ideas and influence. It is the old story of a ruling class that had gone on so long in its own way that it did not see the new world order which was coming. Sun Yat-sen became a revolutionary, and spent the next fifteen years of his life traveling in disguise in China, visiting Chinese colonies all over the world, interesting English, Americans, and other foreign groups everywhere in his vision of the New China, organizing societies, raising money, studying the best methods of government.

It was during this period, when he was hunted as a fugitive and tracked by spies, that he was rescued through the influence of Dr. Cantlie, an English physician, one of his teachers in China, from the Chinese embassy. In a few words he tells the story.

"I was kidnapped at the Chinese Legation in Portland Place, London, by order of the Chinese Ambassador. The story of that kidnapping is already fully known to the world. It is enough to say here that I was locked up in a room under strict surveillance for twelve days, awaiting my transportation on board ship, as a lunatic, back to China, and that I should never have escaped had not my old friend and teacher, Dr. Cantlie, been then living in London. To him, I managed after many failures, to get through a message. He notified the newspapers, and the police and Lord Salisbury intervened at the eleventh hour and ordered my release."

The story of the fall of the Manchus and the beginnings of the Chinese Republic is part of history. So thoroughly had Sun Yat-sen and other leaders spread the teachings of freedom among the Chinese that when the hour came, more than half of the foreign-drilled troops were ready to support at once the revolution against the Empire. Dr. Sun was in London at the time of the final uprising, but was called back to be the first President of the Republic. On February 15, 1912, following out the tradition of Chinese reverence for the dead and belief in their continued interest in the affairs of this

world, he proceeded to the sepulcher of Chu Yuan-Chang, the founder of the old Ming (Chinese) imperial line, and informed the spirit of the Emperor that the foreign Manchu Tartar rule which had lasted for over two hundred and fifty years had been ended, and that the native Chinese were once more in control of their own land and government.

On June 1, 1929, the body of Sun Yat-sen, recognized as the Father of the Chinese Revolution, was laid to rest in a splendid granite and marble mausoleum on the side of Purple Mountain, Nanking, not far from the tomb of the Ming Emperor of the past. In the years between there had been much confusion. Sun Yat-sen was not long in office as President. Generals of the North and South swept back and forth across China with their armies. But the ideals of Sun Yat-sen were gradually prevailing. The procession of representatives of other nations of the world who joined with the Chinese in following his body to its magnificent resting place indicated that his wish had been fulfilled and China had a respected place in the family of nations.

"For forty years," he had written in his will, which he dictated on his deathbed to the people of China, "I have devoted myself to the cause of the National Revolution, the object of which is to raise China to a position of independence and equality among the nations. . . . My experiences during these forty years have firmly convinced me that to attain this goal we must bring about the arousing of our own people, and that we must associate ourselves with those peoples of the world who treat us on a basis of equality."

This will in which he bequeathed his faith in the future of an independent and self-governed China as his legacy to the people is repeated at the assemblies of public officials, at the Monday morning exercises of public schools, and at the opening of every public meeting. Other statements of his concerning the theory of government are part of the creed of the Nationalists, among them the "Three Principles of the People," which are said to be based on Abraham Lincoln's words in his Gettsyburg address concerning government "of the people, by the people, for the people."

Government "of the people" meant to Sun Yat-sen a government based on the principle of national independence. The Chinese nation must not be under other powers. It must have its own separate life as a nation. The Chinese people had shown great loyalty to the family, to the clan, and to the emperor, but had had no thought of the state or nation. They must be trained in that idea.

"By the people" stood in his mind for democracy. The Chinese had not lacked in personal liberty, but had never been called on to sacrifice the interests of the individual to the general welfare, or to join with others in movements for the good of all.

"For the people" meant a government planned, as he put it, on the principle of "popular livelihood," the idea of socialism of each person's being entitled to a suitable living or a chance to earn it.

"Such a government," he declared, "will be the most complete and the finest in the world, and such a state with such a government will indeed be of the people, by the people, for the people."

In the few years before his illness and sudden death in the hospital of the Peking[1] Union Medical College, he did not see his ideas carried out. But in his death he united the lovers of Chinese independence more perhaps than he could have in his lifetime. Opinions differed as to the wisdom of many of his acts and opinions. But, as a writer in the *Peking Leader* well said, "No man has caught and held people's imaginations who did not have within himself certain great qualities of moral courage and unselfish devotion to what he saw as right."

Since the recorded history of the Chinese began, in the days when the Pharaohs were ruling Egypt, the Chinese have always had an Emperor whom they considered the Son of Heaven and whose word was to them the sign of authority. With the end of the Manchu rule that place was left vacant in the popular mind. To place the spirit of Sun Yat-sen in that place, as the symbol of the New China, was to meet the need of a central figure an idea which should give warmth and meaning to the general theory of government. The world waits to see how China will work out its own salvation.

[1] *Now called* Peiping.

Keystone

MAHATMA GANDHI

Dictating at Delhi, India, in 1931, his terms of peace with Great Britain.

MAHATMA GANDHI

IN the winter of 1931 the world saw a sight such as it had never seen before. A single man, small of stature, clad only in a simple white loin cloth, a Hindu *mahatma* or holy man, sat down with Lord Irwin, who represented all the pomp and authority of the British Empire, and negotiated with him terms affecting the "life, liberty, and pursuit of happiness" of his people, the people of India.

A year earlier this man, backed by the devotion of hundreds upon thousands of his followers and fellow-countrymen, set out from his *ashram* (as the place of meditation of a holy man is called in India) to walk with a group of unarmed followers to the seashore, and there, by making salt from the sea water in spite of a British rule that this should not be done, to defy the mightiest empire the world has ever known. Mahatma Gandhi and his followers all over India had been defying the British Empire before. They had carried on a campaign of so-called "civil disobedience" in which they had refused to deal with the officials of the government, and had met the threats of punishment and prison with the simple policy of Gandhi of non-resistance and non-violence. Hundreds of them had spent months in prison. The Mahatma walked straight from his salt-making at the seashore into a prison cell, as must any man who breaks the law. Yet from that cell he came out to deal for India with Lord Irwin.

One must go back of the event to find out more about the man and the movement behind it. Gandhi was born at Porbandar on October 2, 1869, the youngest of a large family. His father was an important magistrate in his province, and his mother a deeply religious woman. He had a good education which was completed by his being sent to England to study law at the University of London. Thus at the

age of twenty he became thoroughly familiar with Western life and customs. On his return he practiced law for a time in Bombay, but already he was beginning to set his life apart for special service. In 1893 he was called to South Africa to use his legal knowledge in defending the rights of a large group of Hindus, his fellow-countrymen, who had gone there to work in the Dutch and British colonies and were being deprived by the government of their rights. He fought for them in the courts and made himself one with them, sharing the insults that were heaped upon them by the ruling classes. After he had himself been imprisoned and made to serve at hard labor, he persuaded the Hindus to practice with him the method of *passive resistance.* They were to withdraw themselves from all relation with the white men, not work for them, not buy from them, simply to have nothing to do with them. There was to be no violence. They would go to prison, as hundreds of them did, until the prisons were overcrowded. But they were not to fight, not to strike back. So in South Africa was tried out the first demonstration of the principle which was to be the keynote of the Indian movement. The South African government yielded at last.

During World War I, Gandhi worked faithfully in India for the Empire, in support of the Allies. But after the war the hopes of Indian leaders and common people that the British would respond to their loyal war-service by giving them more freedom and opportunity for self-government were not fulfilled. A revolution seemed inevitable. In stepped the Mahatma with his plea that the people of India oppose the British not with arms, but with what they called *satyargaha,* a term which means *soul force.*

In no other country in the world would such an appeal have been possible. But the Hindus are an Oriental people with that strain of the mystic and that willingness for self-sacrifice of which martyrs have been made all down the ages. To the call of Gandhi the people responded with amazing enthusiasm and devotion. The cotton which they raised on their own fields was being shipped to England, there to be made into cloth which was brought back and sold to the natives at high prices. Why could not the people spin their own cloth from their cotton? Gandhi set up his spinning wheel and sent his disciples out to preach in every village this return to the ways of their fathers. As a result English merchants could not sell their cloth.

In towns and villages the simplest acts of government were halted because the people refused to deal with the British officials. Out of this civil disobedience came the famous interview with Lord Irwin. From that came the London conference attended by Gandhi. Into the political side of British and Indian relations we cannot go. Nor does it concern our story. We are looking at a man who has spoken to the soul of a nation and made that soul speak back through the deeds of tens of thousands of men and women.

The story might have ended there, but it did not. Other chapters were to be added. Gandhi took up next the cause of freeing the "untouchables," that lowest group in India's system of castes, or social groups, which have always been kept rigidly apart from one another. For the freeing of these "untouchables" he practiced long fasts which stirred the conscience of India and the heart of the world.

In World War II, Gandhi and his followers again resorted to civil disobedience in their effort to win self-government for India. In the spring of 1942, Sir Stafford Cripps visited India as a special envoy of the British Government. He offered India full Dominion status after the war, including the right to separate into two or more Dominions and even to secede from the British Empire, provided the people of India would actively support the British in defending India against the threatened attack by Japan. His mission failed, however, chiefly because Gandhi insisted on self-government at once, not after the war. Gandhi continued to exhort his followers to civil disobedience and in August, 1942, the British arrested the frail seventy-three-year-old Mahatma and placed him in such close custody that he was deprived of newspapers, the radio, and all visits from or letters to his friends. The outbreaks of rioting which followed showed that, imprisoned or free, Mohandas Karamchand Gandhi was still the most important man in India and the spiritual leader of his people.

MAKING CAMP

IROQUOIS LONG HOUSE

THE INDIANS OF AMERICA

(Text and Illustrations by Edwin Willard Deming and Therese O. Deming)

THIS is a new kind of story about Indians. It tells of the ways of different tribes, instead of talking of all Indians as if they were alike, whether they lived in the Long House of the Mohawk Valley or the pueblos of New Mexico.

When the first settlers on the American continent began to get acquainted with the natives, each group of settlers did just what we are likely to do. They thought that all Indians were probably like those whom they happened to meet or know about. It was a long time before they learned that the Plains Indians were as different as possible in their habits and customs from the Woods Indians, or that some Indians lived for generations in the same region, while others were nomads, wandering from place to place like gypsies. They made queer mistakes in naming tribes because they did not understand the different languages.

They did come soon to know, however, that there were a number of separate Indian governments, and that within each government were separate tribes. It is with these tribes that our story begins. We shall introduce you to several of these tribes, as we might introduce you to different members of the same family. We shall see how they have acquired different habits and customs because they lived in different regions. Then, when we have become fairly well acquainted with several tribes, we shall find that some things are true of so many branches of the Indian race-family that it is correct to say, "These ways are Indian."

A TRIBE

A tribe was a group within the larger family. Its members had a common name and an organized government, with laws and rules made and obeyed by the people. The laws were enforced by a band of police. Anyone breaking them was punished.

All Indian life was mutual and co-operative. No one lived wholly unto himself. He saw himself as a member of a group. Not only the laws but the activities of the group were regulated by the council, which was, as we should say, the governing body.

LANGUAGE

Each tribe had its own language. When some tribes met, they could understand one another's language, even though many words were different. Other tribes, though they had talked originally the same "root" or "stock" language,

had changed it so much in the long periods during which they had lived apart that they could not understand what their brothers were saying. Members of the same tribal group could often be traced by the likeness of their speech. For instance, when New York State was first settled by the whites, they found Indians speaking several languages. As they came to know them better, the settlers learned that these tribes called themselves "The Six Nations." While each nation had its own language, the speech was so similar that it was plain that they had probably all descended from the same group or "stock."

THE IROQUOIS

The "Six Nations" are the first Indians with whom we shall become acquainted. The tribes were the Senecas, the Mohawks, the Onondaguas the Oneidas, the Cayugas, and the Tuscaroras. (Travel through New York State to-day, and you will find many of these names retained in the names of counties, villages, rivers, and lakes.)

The Iroquois had the highest type of Indian confederation. Theirs was an organized government, with rules made at a council of sachems. These sachems were elected to the general council by a council in each tribe. The sachem council made laws for the Six Nations, and these laws were accepted by all. A police band was set to enforce them.

When a crime was committed between two tribes, a council was held in each tribe and the crime was talked over. Each council tried to decide how the trouble should be settled. Then the two councils met and made a joint decision by which both must abide.

Chieftainship in the tribe was hereditary, handed down from father to son. But even the chiefs and sachems claimed no superior rights. All had equal privileges. Members of the great tribe-family were personally free, and were bound to defend one another's freedom. Their principles were "liberty, equality, fraternity," though there were no laws demanding them. The "long house" of their councils was to them a symbol of the confederacy. They thought of the whole region in which they lived as a "Long House," and called themselves the "People of the Long House."

THEIR ACTIVITIES

When the Iroquois were first visited by the white men, they were fairly advanced in the arts and crafts. They manufactured nets, twine, and rope from the bark of trees, and made earthen vessels and pipes from clay. They cultivated gardens of maize, beans, squash, and tobacco, and tanned skins to make leggings, moccasins, and shirts. Their principal weapons were the bow and arrow and the war club. Some of their implements were made of flint stone.

Originally the Iroquois were not a warlike people. After many raids were made upon them by the Adirondacs, or Eries, they organized themselves for fighting and became known as the fiercest warriors of the entire East.

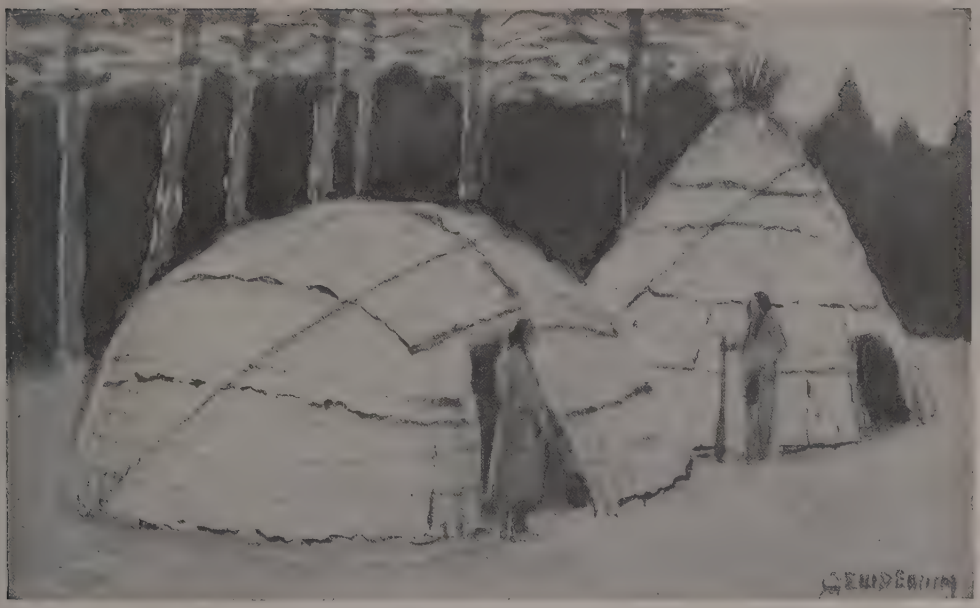
Yet, if an enemy should come for some reason into one of their camps, the people would give him food, and he would be safe so long as he was within their village. Hospitality was an established custom, not only of the Iroquois nation but of all the tribes. If a friend or a stranger entered an Indian home — no matter at what time of day or night — it was the duty of the woman of the house to set food before him.

In early times, during the French and Indian wars, the Iroquois were loyal to the English and fought against the French. (Their territory was a barrier between the English settlements and those of the French and Algonkins.) At the time of the Revolution, they remained loyal to the British and under their leader Tecumseh fought the colonists. They were finally defeated by Harrison, "Mad Anthony" Wayne, and Clarke.

Such is a brief picture of the Iroquois, one of the most interesting and important tribal groups of Indians in the United States.

THE ALGONKINS

The Algonkin was the most widely spread family of Indians. They lived in so many different kinds of region and under such different climates and conditions that they developed among themselves two distinct types. The majority of them were "Woods Indians," with the culture belonging to this kind of life; but those who dwelt on the plains became real "Plains



OJIBWAY (ALGONKIN) HOUSES

From the Algonkin language comes the word wigwam.

Indians." How this would come about can be seen when we learn that they had homes in New England, in the lower Hudson region of New York, in New Jersey and Virginia, in New Brunswick and Nova Scotia, in Ohio, Indiana, Illinois, and Michigan, while three of their tribes, the Blackfeet, the Arapahoes, and the Cheyennes lived in Montana and Dakota, close to the Rocky Mountains, and a fourth, the Crees, settled in Canada. (We come here upon a striking contrast between Indians. This family was widely scattered. The Moki Confederacy, of which we shall read later, had only seven pueblos, all located within a territory of a few square miles.)

Algonkins come very close to us when we know that the Indians who helped the Pilgrims through their first long winter, and such familiar single figures as Powhatan, Pocahontas, King Philip, and Massasoit, were all of this race-group. Several Algonkin words—wigwam, wampum, squaw, and papoose—were so freely used by the white settlers that they have been adopted into the English language. Yet here again it is a mistake to think of all Indian women as squaws, all Indian babies as papooses, and all Indian homes as wigwams. These names belong properly only to the Algonkins.

Because the Algonkins are so widespread, many of their characteristics and customs may be said to represent fairly a large fraction of Indian life. Let us note some of these interesting race habits.

NO INDIAN ALLOWED TO BE A BRAGGART

None of the Indians are braggarts; but if some one did tell a story that his listeners doubted, they had a quick remedy. They took out a medicine pipe; the medicine man painted its stem red; and a prayer was made over it. The medicine man would then say: "Here is the pipe. Accept it. But if you accept it, your story must be as straight as the hole through the stem, and your life shall be long. If your story is not true, you will die soon."

The Indians are very superstitious. If the story were not true, its teller would not accept the pipe. Then everyone knew that he was a braggart.

BIRCH-BARK CANOE

WAYS OF WOODS INDIANS

Among the Indians of the northern woods, birch bark was most useful. Out of it they made their utensils, their canoes, and their homes. Their thread was from the root of the pine, the spruce, or the tamarack, or from the inner bark of the mulberry tree. With it they sewed together pieces of birch bark. They often used sinew for the sewing of their clothing, their moccasins, and their blankets. Like the Iroquois, they used the bow and arrow and the war club; also, the spear, and other weapons. Wild animals were hunted for food, and the skins tanned for clothing. Young animals, which were captured, were often tamed as pets for the children.

Woods Indians made maple syrup, pouring the sap into wooden or bark vessels, then dropping in hot stones to make it boil. This process they repeated until it was sufficiently "boiled down."

A chief food source was the wild rice, which grew in great quantities in the swamp lands. Before the rice was ripe, the women paddled out in their canoes and tied the tops of the rice plants together in bunches, so that the seed, when ripe, could be gathered with the least danger of losing the grain. As it ripened, it was the duty of the children to paddle around in their canoes and drive off the birds which were trying to steal the grain. (The children did not always like this task; but they knew it was their duty, and did it well.) When the rice was ripe, the women would pull each bunch, or bundle, over the side of the canoe, and beat the grain off the tops with sticks, so that it fell into the canoe. They threshed the grain by pounding off the hull and winnowing the chaff. The rice was then stored in birch-bark containers for winter use.

THE PLAINS INDIANS AND THE BUFFALO

The buffalo was so important to the Indian that buffalo hunting was carried on by set laws. When a herd was seen, the news was at once reported to the leader of the hunting party. He had the men called, and the hunt started. If a hunter went out alone to hunt buffalo, or even if he disturbed a herd by accident, he was punished by the police. This was because buffalo was the main food stay of the Plains Indian. The dried buffalo meat was pounded into shreds, placed in skin bags, and mixed with hot fat. To this was added wild cherries or other berries, also pounded, and the mixture was called "pemmican." Pemmican was a great food among the Indians. It would keep for a long time, and could therefore be stored away for times of need. The skin of the buffalo was used for robes, tepees, and bags; the hoofs were made into glue; and the horns furnished spoons. No wonder the buffalo hunt was made a tribal matter with set rules of action!

There were usually two hunts a year, one in winter, the other in summer. The whole town went, partly out of fear that those who stayed behind might be attacked by some enemy. All valuables and provisions that could not be moved were buried. And so, single file, they started, often to travel, before they returned, many hundreds of miles. The scouts rode ahead, always on the lookout for the herd. When, at last, the animals were sighted, camp was made.

There were many ways of hunting the buffalo. In winter it was done on snowshoes, for the animals were helpless in deep snow. Sometimes the hunters speared them, sometimes shot them with bow and arrow. One of the most successful ways was to drive them over a cliff. If the cliff was high, the animals were killed when they fell. More often, however, a low bank was chosen, towards which it was agreed that the oncoming herd should be lured. A corral of rushes was hastily built at its foot. The animals would plunge over the bank and fall into this corral. While they were milling around, trying to find a

way out of the enclosure, the hunters on the outside could shoot them.

If the herd was attacked in the open, the hunters tried, when the word to charge was given, to get abreast of the animals, or as near them as possible, and spear or shoot them. Each hunter's arrows had his own special mark. When the hunt was over, the women went out to skin the animals and cut up the meat. They examined the arrow that had killed each animal, then dressed those killed by members of their own family.

The Algonkins did much of their carrying by the aid of the "tump line," a broad band across the forehead, with two long thongs fastened to its ends. The pack was tied with the two thongs, and then placed on the back, so that the pull came on the forehead as well as on the shoulders.

IN BRIEF

What then — as we leave the Algonkins to become acquainted with another tribe — shall we remember especially about them? That they lived in many regions; that members of different branches of this tribe were both close friends and bitter foes of our early colonists; that they had two distinct habits of life, according to the place where they lived, the habits of woodsmen and of plainsmen; and that the Plains Indians hunted buffalo. Among their special foods were pemmican, made from buffalo meat, and wild rice. Herbs were valued both for food and medicine. All the tribes used tamed wolves for beasts of burden. The wigwams of the Woods Indians were usually made of birch bark; those of the Plains Indians were of buffalo hide.

PLAINS TEPEE, MADE OF SKIN

When the Indians of the Plains left their settlements to go on buffalo hunts, they took with them skin tepees for their camps. Often they traveled hundreds of miles on these hunting trips.

THE SIOUX, OR DAKOTA, INDIANS

This was one of the largest Indian groups, with homes in North and South Dakota and in Minnesota. The Sioux Indians were originally known as the Lakotas and the Dakotas; but when the French asked their name of the Ojibways who lived to the west of them, the Ojibways answered, "Na-Da-Wa-Sioux," which in their language meant "The Enemy." Not understanding, the French thought they were giving them the name of the tribe, which they shortened to the "Sioux," the name by which they have since been known. Among the Sioux are the Winnebagos, the Poncas, the Omahas, the Osages, and many others.

NOMADS, HUNTERS

Many were nomads, wandering back and forth on the plains of the great Middle West. They covered an immense tract of land extending from the Mississippi westward beyond the Missouri and southward to what is now Oklahoma. Though there were many dialects, all the Plains Indians had a sign language by means of which they could make themselves understood as easily as with the spoken word. Their intercourse was, however, by no means always friendly. They were warlike peoples, and were nearly always fighting with some of their neighbors.

The bringing of the horse to America by the Spaniards provided the nomads with a new beast of burden, and enabled them to travel both faster and farther than before. Some tribes settled in villages and built tepees or earth lodges. For food they raised corn, squash, and tobacco, and dug many edible roots. But, in general, they were nomads, living chiefly by the hunt. A large company would spend each summer following the buffalo herds. They hunted also the mountain sheep, the goat, the elk, the bear, and the antelope, storing the meat for winter and dressing the skins for many uses.

HAIDA HOUSE

IN WINTER

When winter came, the tribes separated into small bands, making camp in the foothills at some spot where there was plenty of water. Winter was the time for story-telling. The old men and women recounted the tales of the tribe, which the young Indians heard eagerly and treasured in their memories, so that some day they should tell them to their children and children's children and so do their part in carrying on the records of the tribe. As soon as the grass was green, so that the horses could find food, they would break their winter camp and start off again on the hunt or on the war path.

BURIAL OF THE DEAD

The Plains Indians buried their dead on scaffolds or in trees. When a Sioux warrior died, his body was dressed in his finest clothing, and his face was painted as if he were going to a dance or feast. Bow and arrows, and food were left at the grave. His horse was killed, so that his spirit could ride in the other world the spirit of his favorite horse. The people did not think that he actually used the food and other things, but they thought that everything had a spirit. The spirit of the departed might make use of the spirits of these former possessions.

His wife went to the grave to mourn, and the weird wail of her mourning could be heard for a long distance.

THE CHINOOK — CANOE INDIANS

The Chinook, or Columbia River, Indians were canoe Indians. They were short and heavy set, with legs bowed from having spent most of their lives in canoes.

These canoes were dugouts, made from yellow cedar logs. Sometimes a single canoe was long enough to carry from thirty to sixty people. With only the stone tools which they had at their command, it was a great task to hollow out one of these huge logs and shape it for its purpose. Many were carved and painted at both ends, and each had an eye painted on the prow so that it could see where it was going. The paddles had long, slender blades. These, too,

DUGOUT CANOE
Made from yellow cedar logs.

were often painted and carved with designs.

The Chinook built their villages in a long line along the shore of the river or the sea. Their houses were of boards. In front of each house was set a totem pole on which was carved or painted in symbols the history of the family which lived within. They gained the name of "Flatheads" from a curious habit of fastening a board to the case in which a little baby lay in such a way that it pressed against the baby's head. The flattened forehead was to them a mark of beauty.

The Chinook Indians lived largely upon fish, which they dried and packed away for times of need. They were especially fond of oil which they got from a little fish called the "candle fish." You remember how the Woods Indians dropped hot stones into the sap drawn from maple trees to make it boil. The Chinook used a similar method for getting the candle fish oil and "trying it out." They put water into a canoe, threw in a large number of the little fish, and then dropped in hot stones. As the oil rose to the top of the water, it was carefully skimmed off and saved. A dish of this oil was always to be found at Chinook meals. Into it were dipped dried fish and dried cakes, made from seaweed or berries or scraped cedar bark.

The Chinook were skillful craftsmen, weavers of beautiful baskets and fine blankets.

PUEBLO ADOBE HOUSE

Spanish explorers found the New Mexico Indians living in these houses.

PUEBLO INDIANS

From the nomads of the plains we turn to a group who are known by the name of their homes. "Pueblo" is the Spanish word for village. When the Spaniards found Indians living in towns and villages, they called them "Pueblos," and the name has since been applied to these tribes. Spanish explorers found about one hundred such villages. To-day only twenty remain. All of them, except seven Moki villages in Arizona, are in New Mexico.

It is a beautiful country in which the Pueblos live — a desert country, with wind-carved, flat-topped mesas, broad valleys, and narrow canyons. They are an agricultural people, cultivating corn, wheat, watermelon, muskmelon, squash, tobacco, and gourds. These last are used for all sorts of utensils; even the rattles, used in the Pueblo dances, are made from gourds. The Pueblos make pottery and baskets. Both men and women weave blankets and belts.

LIFE IN A PUEBLO

In early times, a pueblo, or village, consisted of a few great houses, each house being the home of a large number of families. The old pueblo at Taos still remains as an example of that type of dwelling. The houses have flat roofs. As one roof rises behind another, the different stories look like flights of very wide stairs. The roof of the front row of houses is the platform for the second story of houses. For these ancient houses there were no doors. Ladders reached from one roof to another, and the houses were entered through openings in the roofs. Now there are doors, but ladders are still used for climbing from

one story to another. Pueblos were planned in this way for safety, for their dwellers were a peaceable, agricultural people, and doubtless suffered in raids by their more warlike neighbors.

The houses were built of adobe, or sun-dried brick. (See Volume Four, page 219.) A village was always located near a water supply, so that the women could fill their water jars easily and carry them to the homes.

The Pueblos are an industrious people, both men and women sharing in the work of the home and village. Within the pueblo is a corral into which are driven the goats, burros, and ponies which the boys bring in every evening from pasture. Every pueblo has community bake ovens where the bread is brought to be baked. A bake oven is a little adobe mound with an opening at the bottom where the mound is hollowed out. In this hollow within the mound the women build on the hard ground a fire of dried brush. When the oven is thoroughly heated, the coals are raked out, and the bread is put in to bake. A sheepskin is hung over the opening to keep in the heat. After about an hour, the bread is taken out, well baked.

Bread is made from corn or wheat, ground fine on a large, hollowed-out stone by rubbing with another smaller stone. The wheat has been previously threshed in an enclosure like a corral. For this process a hard piece of ground is selected. Poles are set around it, and ropes tied from pole to pole. The wheat is thrown on the ground, and ponies or burros are driven in. A boy with a whip keeps the animals running round the enclosure until the grain is pounded from the husks by their hoofs. The grain is swept together and put into baskets; the women winnow it by tossing it in the wind, which blows away the chaff.

The Pueblos have many dances, most of them religious. Because the country is dry, the rain dance is very important. There are hunting dances for luck on the chase, and harvest dances of thanksgiving for good crops. The Mokis, of the Arizona pueblos, are famous for their Snake Dance.

THE MOKI SNAKE DANCE

The Snake Dance requires nine days, and sometimes longer, for its celebration. It is the Moki prayer dance for rain. Most of the rites are secretly performed in the *kiva*, or council house.

During the first days runners are sent out to place prayer sticks at springs and sacred places. On the fifth, sixth, seventh, and eighth days hunters go out to capture living snakes. One day is devoted to each point of the compass; the first day they go to the north, the second to the west, the third to the south, and the fourth to the east. Any snake that is seen is taken, but the rattlesnake is most prized.

At noon on the final day, a great bowl is brought into the *kiva*, and all the snakes that have been captured are washed, while the Indians sing and beat time. The song starts in a low, weird chant which gradually increases into a war cry. Those who are to take part in the dance come out of the *kiva*, and after dancing four times about the square, or plaza, separate into groups of three. One man takes a snake, and puts the squirming reptile into his mouth, holding it at about the middle of its body. The second man dances beside him and attracts the attention of the snake with a feather wand. A third dances behind these two. In bands of three the dancers encircle the plaza four times. Then the snakes are dropped. As the snake falls, the third man of the trio catches him. The medicine man has made a ring in the center of the plaza. The snakes are thrown into this magic circle. Now the sacred priests rush in, seize all the snakes they can, and run down the trail into the open country, where they release them to go where they please. While the snakes are being loosed, a group of priests marches four times around the plaza, praying for rain. This ends the ceremony.

MOKI PUEBLOS

The Moki pueblos are built on the crests of mesas. The houses are of stone instead of adobe. The Mokis are famous for their weaving. A dark blue or black woolen dress woven by them is now worn by the women in all the pueblos. They also weave wonderful blankets.

This country is also the land of cliff dwellings. These homes were cut into rock long before the white man came. They were probably occupied by ancestors of the present Pueblo Indians. for

ESKIMO IGLOO

pieces of broken pottery found in the cliff graves are similar in design to the modern Pueblo pottery. Some of the oldest pueblos, built on the top of mesas, are almost impossible to reach, with only a single, half-hidden trail leading to them. These cliff homes were probably used as a refuge by the peaceful Pueblos when the warlike Apaches and Navajos made raids upon them and carried off their crops.

THE ESKIMO

Now we turn northward to the Eskimo family, whose territory extends coastwise from eastern Greenland to western Alaska and to the westernmost point of the Aleutian Islands, a distance of more than five thousand miles. All the Eskimos except those of the Aleutian Islands speak dialects which come from one stock language, a speech closely related to that of peoples of the Chukchi peninsula of Asia.

Their permanent winter villages are scattered along the coast, at great distances from one another. The homes in these villages are *igloos* made of snow blocks. When parties go inland in summer to hunt caribou, they carry with them tents of walrus hide.

The Eskimos subsist chiefly on their fishing and their seal-catching. The seal provides almost everything an Eskimo may need — shelter, light, heat, clothing, and food. They dress in clothing made from seal or caribou skin; they eat seal meat; they light and heat their homes with seal oil burned in open lamps; and they use the skin for all sorts of other purposes.

THEIR CLOTHING

In the cold part of the year, Eskimos wear two sets of clothing, one with the fur side out, the other turned so that it is next to the body. Both men and women wear shirts, pulled over the head and with hoods attached, and trousers. The men's trousers reach from hip to ankle. Their feet are covered with socks of skin over which skin boots are drawn. The lower garments of the women combine sock and trousers. They, also, wear skin boots. The hood of the shirt is faced with wolverine skin because it does not gather frost.

BOATS AND HUNTING

The Eskimo uses two kinds of boat, the *umiak* and the *kaiak*. The first is a large boat with a framework covered with walrus skin. It is seaworthy and will carry many people. The *kaiak*, also skin-covered, is a one-man boat with a small opening in which the man sits with an apron tied around his body to make the boat absolutely waterproof. In it he can turn himself upside down and back again with ease, as he often has to do when he is following a walrus or norwhale which he has harpooned.

The harpoon is a long spear attached by a string to a sealskin bag filled with air. He throws the harpoon at the animal he is hunting. The animal, thus speared, may dart away, but the sealskin floats, thus enabling the hunter to locate the animal and follow in his *kaiak*. At night they pull their boats on shore and turn them over to dry.

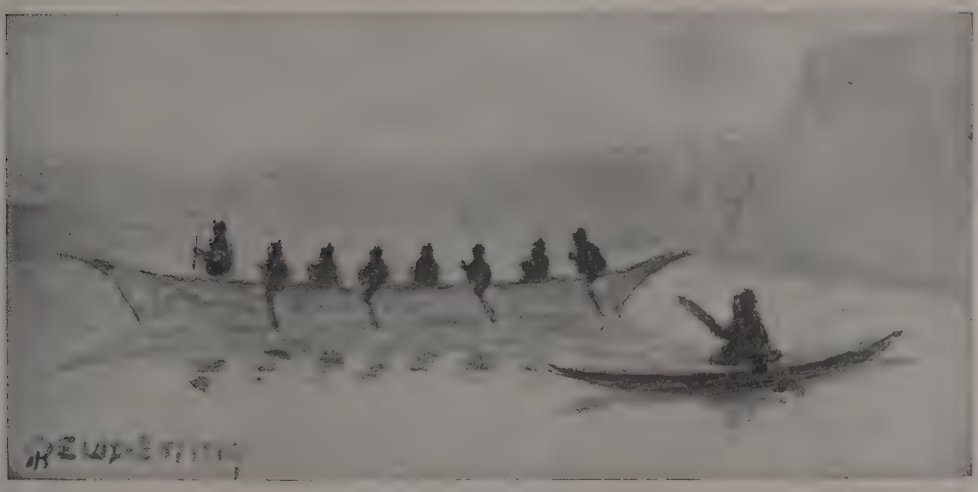
Eskimos hunt seals, norwhales, and fish with spears or nets, and ptarmigan and water fowl with nets and snares. Bows and arrows are also used. Their tools are made of bone, or of ivory from walrus tusks. Bags for carrying water are made from the stomach or bladder of the caribou. They also hunt musk oxen, wolves, bears, foxes, rabbits, and many marmots.

THE ARCTIC SUMMER

Though the weather is very cold in winter, it is surprising to know that during the months of the Arctic summer there are many days as warm as the hottest days in the temperate zone. During this time the country blossoms with plants and flowers. Mosses, lichens, and ferns cover a goodly portion of the ground. There is little rain, but the continual thawing keeps the ground moist. Mosquitoes and flies abound. In this land of the midnight sun, the plants have twenty-four hours a day in which to grow.[1]

GAMES

Men, women, and children play games. Boys have toy hunting outfits, toy *kaiaks* and *umiaks*, small bows and arrows, and sleds. Little girls play with dolls made of ivory, and have sets of small dishes shaped like those of their mothers. Some of the games are very much like ours. They play cat's cradle with skin thread made of sinew, spin tops, throw darts, and jump rope. Groups play hide and seek, blind man's buff, and tug of war. Boys and men have contests in arm pulling, wrestling, high jumping, foot racing, and *kaiak* racing. And men, women, and children play football!



ESKIMO KAIAK, A ONE-MAN BOAT, AND UMIAK

[1] See also Volume Ten, pages 290 and 296–298.

EARTH LODGES, HOLDING MANY FAMILIES

INDIAN CUSTOMS AND WAYS

WE have followed Indian tribes from the Atlantic coast to the plains of the Northwest, and from the pueblos of New Mexico to the igloos of the Northland. Now we are ready to turn to the habits and customs which belong to so many tribes that they are a part of Indian life.

KEEPING RECORDS

The Indians had no written language; yet there were many events of which they wished to keep records. They depended chiefly on the memories of their story-tellers, who passed the tales on, sometimes in the form of legends, from generation to generation. Some of the Algonkin tribes scratched pictures on birch bark. They were a help if the story-teller needed to be reminded of any part of his story. Algonkin blankets, and Algonkin and Iroquois wampum belts, helped to remind them of important events, a belt giving in picture or sign every detail of a treaty. Pueblo picture writing was done on the rocks.

The "winter count" was an important tribal record. Into it was drawn each year a picture of the most important event that had taken place during that winter. The date of a child's birth would be counted from the winter of a certain important event as recorded in the "winter count."

The Aztecs of Mexico and Central America went farthest in the development of picture writing. They kept a real history, and gave in picture symbols the directions for the worship of their gods. They even made a sort of soft paper from bark, and wrote books in picture writing. The covers of these books were made of thin boards, decorated by the inlaying of polished stones.

TIME TELLING

Time was recorded in various ways. When one person set a time to meet another on the same day, he would say, "Let us meet when the sun has traveled across the sky to ——," mentioning a certain point. For a time many days away, he would say, "After so many sleeps." If it was to be after several months, he indicated it by the number of moons; if years, by the number of snows. Time at night was told by the position in the sky of the seven stars of the Big Dipper.

INDIAN HOUSES

We have spoken of several kinds of Indian houses. The Woods Indians made wigwams of birch bark; the Plains Indians fashioned tepees of skins; the Indians of New Mexico built pueblos of adobe; the Arizona Mokis lived in stone houses. Other tribes, among them the Pawnee, Omaha, Grosvente, Aricaree, and Mandan Indians, lived in great earth lodges. A single lodge was often sixty feet in diameter. To build it, they set up a circular framework of poles upon which they piled brush and earth. The outside was then plastered with mud. A long, covered entrance was built, in which the war horses were often stabled. If they were left outside, there was danger of their being stolen by the enemy. When these Indians left their lodges to go on hunting expeditions, they carried with them skin tents.

WAMPUM

For money with which to trade the Indians used wampum shells, of which there were two kinds, white and purple. The purple shells were the more valuable and were rated as we would rate gold, but the white wampum was also good in trade. Wampum shells had been originally used as ornaments, but came to be employed almost wholly as an article of exchange, or

SEMINOLE HOME

money. The Algonkin and Iroquois tribes used wampum belts in making treaties.

Shells of some sort passed as money in most tribes, though they used also the articles most valued by them — turquoise in the case of the Pueblos, blankets by the Navajos.

CLOTHING

Most of the Plains and Eastern Indians wore clothing made of tanned skins. The men wore as a breech cloth a piece of skin a foot wide and several feet long. This was held in place by a skin belt. A pair of leggings, a shirt, and moccasins completed their costume. The woman's dress was in one piece, reaching from the neck to the ankle. She wore also short leggings and moccasins made of skin and decorated to suit her taste.

ORNAMENTS

Indians were fond of ornamenting their clothing. In the early days they used porcupine-quill or moose-hair embroidery, but in later times decorated them with quantities of beads. Both men and women liked necklaces. Before they could get beads, they made their necklaces of shells, bones, animal claws, and even of stones.

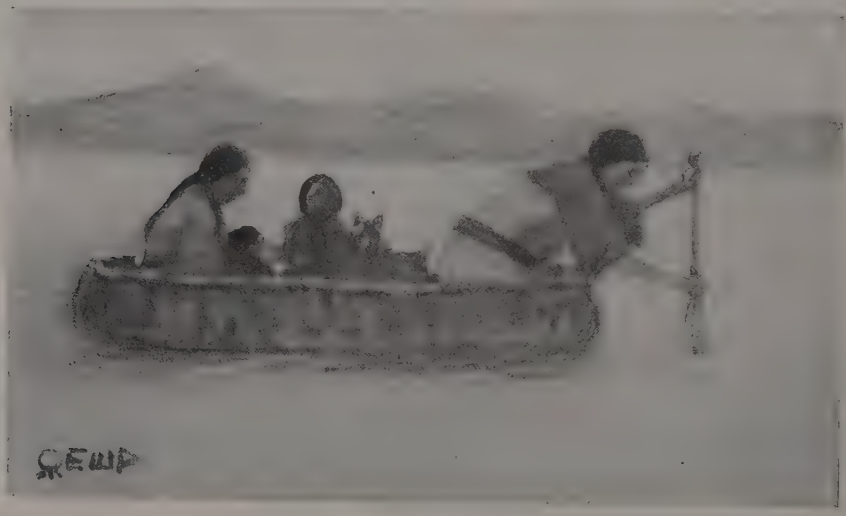
MOCCASINS

Moccasins are purely Indian in origin, and have always borne the Indian name. They are foot-coverings with no heel, and usually reach to the ankles, where they are tied with a buckskin cord. Different tribes had different designs for shaping their moccasins. (A moccasin print in the soft dirt or snow would often reveal the tribe of which its wearer was a member.) The Woods Indians made their moccasins with soft soles, but the Plains Indians and those living in the land of the cactus wore moccasins with rawhide soles.

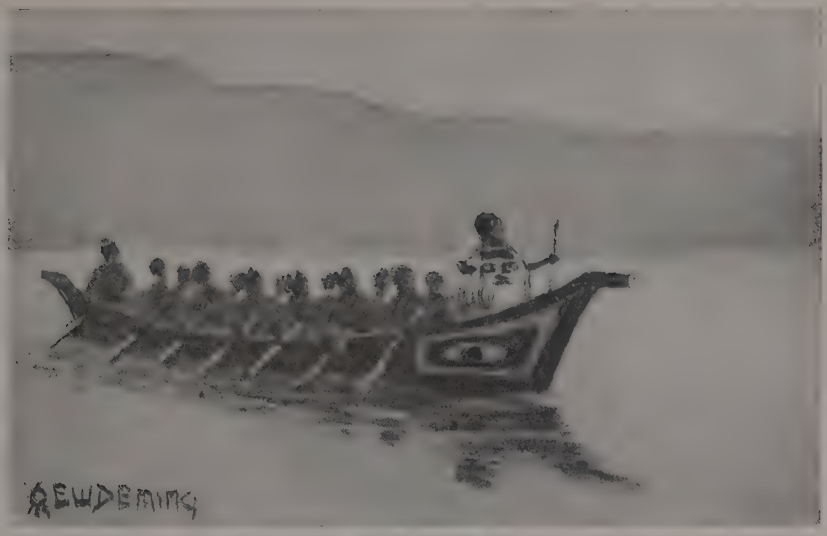
BABY BOARDS

You remember that the Chinook Indians tied small pieces of board across the foreheads of their babies as they lay on their "baby boards." Almost all tribes carried their babies on boards, which had arched pieces of wood over the head so that the baby's face would not be hurt if the board fell. From this head board, the mother hung ornaments with which the baby could play.

The baby board could be hung from the limb of a tree, or could lean against a bush, the trunk of a tree, or the back of a tepee, while the mother went about her work. For traveling on horse-



BULL BOAT, SKIN-COVERED



HAIDA WAR CANOE

Notice the painted eye on the prow so that the canoe could see where it was going.

back a hook was carved on the mother's saddle, so that the baby could ride along wherever she went.

THE CANOE

The canoe is an Indian boat. The one most used, on which our modern canoes are patterned, was made of birch bark. The dugout canoe, hollowed laboriously out of a long log by stone tools and the use of fire, was also made by the Indians. A few tribes had the "bull boat," a light circular framework covered with skins, useful for ferrying parties across rivers and streams.

THE CAMPFIRE

Fire was sacred to the Indian, and a campfire was always kept burning. A fire was started with a spark made with fire sticks, or, among the tribes of the Southwest, with a fire bow. When a tribe moved, fire was carried from camp to camp in a buffalo horn.

Besides its use for light, heat, and cooking, and in sacred ceremonies, fire was employed for signaling. A high signal spot that could be seen for long distances was selected. Tribes had their codes and reported to one another, using smoke for signals by day and flame by night.

IN AN INDIAN HOME

Indian home life had many customs of courtesy. When a visitor arrived, he entered the lodge and seated himself at the right of the door. If the chief wished to do him honor, he invited him to sit at his left. The chief's family sat at his right.

It was very impolite to pass between the chief and the fire.

When a stranger came to a chief's tepee, food was set before him. Even though it was known that he was the bearer of an important message, no question was asked him. When he had eaten, then he would deliver his message.

Neither in the house nor at the council did anyone ever interrupt a speaker. When the speaker had finished, he would say, "I have spoken." Then another could speak.

If an Indian was asked his name, he would not answer. A friend, standing by, might say, "His name is Enemy-taker," but the man would not give that name to himself. He had earned his name; it had a special meaning. To give it himself would be considered boasting.

At an early age the children were taught these little politenesses. Above all, they were taught respect for their elders.

The Indian woman was the owner of the lodge. Hers was the labor connected with it, — the tanning of skins, the drying of meat, the gathering of wood, the making of clothing, and other domestic duties. She would have had little respect for her warrior if he had helped her with these tasks. He had to procure the food, often going long distances and enduring great hardships to keep his family supplied. It was his duty, too, to defend his lodge against the enemy.

The Indians are often represented as sullen and silent, never smiling or joking. This is a mistaken idea. Among themselves they are always joking, but with strangers they are grave and silent. Perhaps they are naturally shy. But when they become acquainted, they are cheerful companions.

INDIAN FOLKLORE

TO know the heart of a people, one must know their folklore. Indian folk tales and legends show a spirit of reverence and awe. The Indians believed that there were spirits all around them. Everything had a spirit — the trees, the leaves, the plants, the winds, and even the mountains.

They worshiped the Great Mystery. When a boy reached the age of ten or twelve years, he was taught of the Great Mystery. After that he never mentioned the name. He learned about Him, but his prayers to Him were offered in silence, alone, far from camp. He never prayed to Him for selfish needs. For these there were the helpers of the Great Mystery, the Sun, the Moon, the Stars, and Mother Earth. The Sun, the Lightbringer, was the creator, the first among the helpers. It brought everything that was good, — health, happiness, luck on the chase, long life, and strength. It was the father; the moon, the mother; and the morning star, their son. In time of illness a prayer was made to the sun, and a thank offering was given after recovery.

The stars were thought to be animal spirits, crossing the skies from east to west. The Milky Way was the trail for the spirits of the "man people" as they traveled across the skies.

FOLK TALES

In the Indian folk tales there was a reason for everything, and most stories had a moral. Indian children knew why the rabbit had long ears, why there was an echo, why the raccoon had a striped tail, and why the raven and the crow were black. They were taught never to kill an animal "just for fun." If they did, they were punished. They knew the stories of the stars. Mists, to them, were beautiful maidens dancing on the water and in the air.

One of the prettiest stories told was of the little fawns. When they died, the spirits left the bodies as little yellow butterflies. Children would never try to catch these butterflies when they saw them fluttering about. They felt sorry for them, and were happy when they saw two flying about together, for the spirit of one little fawn had found another fawn spirit to play with. A single butterfly might be a new little spirit, looking for a companion.

There were myths of how the world was created, how man was made, how fire came to their forefathers, and why one animal had more power than another. (Some of these stories you can read in Volume Five, pages 107–135.) The bear was strong and hard to kill; all his senses were very keen. He had the power of healing and was the totem of the medicine man. The raven and the coyote were cunning. The wolf had endurance, and was very crafty. The badger was wise. Men going on a hunting trip sang wolf songs, as they were supposed to bring good luck.

Stories were told in winter when the snakes were asleep and could not hear them. If the snakes should hear them, they might carry them to an enemy tribe. They were told at night, when the birds, too, were asleep.

PRAYERS

Prayer preceded every important act of an Indian's life. Before food was taken, some of it was held up as an offering to the Great Mystery, and then dropped into the fire, so that its smoke would rise to the spirit land. Smoking was a sacred rite. When the pipe was taken out, it was offered to the four corners of the earth, to the Great Mystery, and to Mother Earth. Then the chief took a few puffs and passed it to the man at his left, who in turn passed it on until it had gone around the circle.

Prayer dances were held, as we have read, be-

fore special undertakings or in times of need. Before an Indian entered a religious dance he purified himself, first by steaming himself in the "sweat lodge," and then by a plunge in the stream.

The first thunder was a warning from the Great Mystery that spring was coming and people must be getting ready to plant.

Some spirits were good and always helped. Others were evil. The good ones would do no harm, but the bad ones must be propitiated. Medicine men spent their lives trying to appease the evil spirits. They were supposed to gain magic power with which to oppose them. If an Indian were ill, he sent for the medicine man. An evil spirit had entered his body bringing illness. The medicine man must try by his weird songs and incantations to drive that spirit out. Herbs helped, too, by making good medicine; and a medicine bag tied around the neck often brought good luck. The medicine bag was not for healing but was filled with various objects supposed to have magical power. Each brave had his own medicine bag.

In all his religious life the Indian sought health, prosperity, and peace. His prayers, his offerings, and his sacred dances were all to that end. He lived surrounded by spirits and in the presence of the Great Mystery.

WIKIUP — AN APACHE HOME

Courtesy, U. S. Dept. of the Interior

YOSEMITE VALLEY, YOSEMITE NATIONAL PARK

OUR NATIONAL PARKS

By Isabelle F. Story
Editor-in-Chief, National Park Service.

SCATTERED throughout the length and breadth of the United States—and even extending to the far-off territories of Hawaii and Alaska—is a series of public recreational areas. They were established for two very definite reasons—to conserve their natural beauty and other objects of interest for the use of Americans of all generations to come; and to make them available today for such of our citizens and our foreign guests as have the time and opportunity to visit them.

Americans should be proud of their national parks, not only because they contain the most wonderful scenery in a country replete with scenic interest, but because they set the example for a new type of land-use which has been followed all over the world. Until the first national park, the Yellowstone, was established in 1872, such public use of the best lands of a country was unheard of and unthought of. It was expected that the choicest lands would be reserved for the rulers and other mighty of the earth. For instance, when the Kings of England were at the height of their power, it was one of their most cherished prerogatives to take possession of any area they wished and convert it into a hunting preserve for their personal pleasure. But the Kings went too far, and finally the barons combined with the common people to force on King John that great constitutional code, the Magna Charta, in which were set down certain laws limiting the kingly powers in the disposal of such lands. But still no thought was given to great parks for the people generally; farms they perhaps must have, if life were to be maintained, but parks still were retained for the ruling few.

THE STORY OF THE YELLOWSTONE

It was a long step, in years and in social progress, from the compulsory issuance by King John in 1215 of the Magna Charta to a day in 1870, out on the western frontier of the

United States, when a group of men voluntarily gave up their legal and moral right to profit through the ownership of the area now included in Yellowstone National Park, and instead started a movement that in two years resulted in the creation of our first national park. The story behind the creation of the Yellowstone is one of drama—of adventure and exploration, of conflict with the Indians, and of high idealism.

Long, long ago—in 1807—John Colter, who had been a private soldier in the famous Lewis and Clark Expedition to the Northwest, decided, when he had fulfilled his duty as a member of that expedition, to leave his comrades and make the return trip on his own, going into the region now included in Yellowstone and Grand Teton National Parks. So far as is known, Colter was the first white man to visit the area. And when he came back with stories of a land that gushed forth water to great height, and mountains that smoked and roared—as well as tales of narrow escapes from hostile Indians—people could not and would not believe that such a land existed. So derisively they called it "Colter's Hell" and him one of the world's worst prevaricators.

Some years later other adventurers wandered into the region, but most of them were afraid to say much about what they had seen, knowing that they would be labeled untruthful if they reported the evidence of their own eyes. The famous scout Jim Bridger was one of those who knew the region, and one of the few who told the world about its marvels. When people laughed and refused to believe, Bridger embellished his stories into impossible whoppers, but always, in the most fantastic of his stories, there was a basis of truth.

Finally, in 1870, the Federal Government sent an official exploring party into the region, either to prove or to lay at rest the stories of strange natural wonders there. This party is called from its leaders, the Washburn-Langford-Doane Expedition. These hardy folks spent about a month in the Yellowstone area, exploring, discovering, and often suffering great hardship. Then one evening they sat around a campfire near what is now known as Madison Junction discussing what they had seen during their month of adventure, and talking about the best disposition to make of it all.

Courtesy, National Park Service

STARK PEAK, GLACIER PARK

They were men with families and friends for whom they wanted to do great things. Among the plans proposed was that of partitioning the area, one man taking the geysers, another the Yellowstone canyon, and so on. To file claims upon such areas was in accordance with the land laws governing the public lands of the West. It was the natural thing to do, particularly at that time when the social conscience of the world was not greatly developed. Then one man spoke—and not only the members of that little campfire band but later the whole world listened. For he proposed a very revolutionary idea. The Yellowstone area, he said, was too wonderful, too different from anything

else in the country, to be partitioned for private exploitation, even though the explorers had every moral and legal right to take such action. Rather, he urged, it should be saved as a national park, for all of the people of the whole nation. The daring idea fired the enthusiasm of his hearers, who sponsored the successful movement to establish Yellowstone National Park, which by Act of Congress approved March 1, 1872, was "dedicated and set apart as a public park or pleasuring-ground for the benefit and enjoyment of the people."

The man who made the momentous suggestion that resulted not only in the creation of that park, but in the magnificent national park and monument system the United States has today, and also of national parks throughout the entire civilized world and on all continents, was Cornelius Hedges, a lawyer of Montana. To him every visitor to a national park owes a deep debt of gratitude.

HOT SPRINGS OF ARKANSAS

Even before the idea of national parks was born, the United States Government had reserved the Hot Springs of Arkansas—as early as 1832—because their waters were believed to possess healing qualities which should be available to all alike. The Indian tribes of the region knew the medicinal properties of these waters long ago and battled for possession of the springs; then they declared a truce, that all might benefit from them. So the Great White Father in Washington who signed the act setting aside the Hot Springs Reservation for the use of all Americans was merely following the good example set by the Indians. Later, in 1921, Hot Springs became a national park and now is developed for its recreational possibilities as well as for the use of its healing waters.

OTHER NATIONAL PARKS ESTABLISHED

After the establishment of Yellowstone National Park, no others were created until 1890, when Sequoia, Yosemite, and General Grant, in California, were established. In 1899, Mount Rainier in Washington came into the system. Since the turn of the century, more than a score of other national parks have been established.

THE NATIONAL MONUMENTS

Another important category in the system includes the national monuments. These are established by Presidential proclamation, under an act approved June 6, 1906, known as the "Antiquities Act." In its exact wording, the act gives to the President of the United States authority "to declare by public proclamation historic landmarks, historic and prehistoric structures, and other objects of scientific interest that are situated upon the lands owned or controlled by the Government of the United States to be national monuments."

These areas run the gamut from the ruined dwellings of Indians who lived a thousand or so years ago to historic areas of the middle nineteenth century; from trees and plants petrified—apparently turned to stone—millions of years ago, to magnificent groves of living giant trees.

By far the greater number of monuments are rich in human associations. Those of the Southwest in particular are a vast storehouse of treasures of antiquity. Research constantly brings to light new facts about the peoples who lived on that part of the continent long before the footsteps of the first white man were recorded only temporarily in the shifting desert sands.

For instance, by removing tons of earth literally shovelful by shovelful, by hand labor, a few years ago a vast apartment house was uncovered that was built and occupied probably a thousand years ago. Often a sealed-up cave is opened, to disclose a great earthen jar, perfectly preserved, that was made by hand hundreds of years ago. Such a find makes one think; think particularly of the fact that to make that bowl some person, probably an Indian woman, carried water on her back up a steep cliff from some far-away water hole or creek. Life was a very different thing in those days from what it is now.

MILITARY AND HISTORIC PARKS AND OTHER COMMEMORATIVE AREAS

Although the preservation of historic areas is provided for within the scope of the Antiquities Act, in addition Congress by special laws has established a number of national

military parks and battlefield sites to preserve areas where the history of our country was written indelibly in the blood and sacrifice of its sons. The events so commemorated go back to the early French and Indian Wars and come down through the Revolution and the War of 1812 to the War Between the States.

Other classifications in the national park and monument system are miscellaneous memorials and national cemeteries, all historical in character and chiefly military. One of the memorials includes Kitty Hawk, at Kill Devil Hill, North Carolina, the place where the Wright brothers made the first sustained flight of a heavier-than-air machine.

NATIONAL PARKWAYS

The newest type of recreational area in the park and monument system are the national parkways. These in reality are elongated parks through which roadways run. An example of this type of recreational development is the Blue Ridge Parkway connecting the Shenandoah National Park in Virginia with the Great Smoky Mountains National Park in Tennessee-North Carolina.

In all, there are now more than a hundred separate areas which together make up our famous national park and monument system.

WILDLIFE SANCTUARIES

All of the areas within the national parks and monuments are absolute game sanctuaries; and one of the most fascinating features of the national parks and larger monuments is the opportunity they afford visitors to meet face to face wild animals such as their pioneer forefathers encountered in moving westward from the Atlantic seaboard. Not so many years ago many of these species roamed over most of the entire United States in vast herds. Today, outside of zoological parks, there are comparatively few places where they may be viewed, and of these places the national parks take first rank.

Although hunting is strictly banned in the national parks, fishing is permitted under regulations that insure against depletion of the fish supply.

The waters of several of the parks contain excellent native game fish. To insure continued good fishing, many millions of fish eggs and fingerlings are planted each year in park lakes and streams through the cooperation of Federal and State fish hatcheries. Every effort is made to improve fishing conditions and afford good sport for the thousands of anglers who seek recreation in the parks.

LOCAL ADMINISTRATION

Each of the national parks, including the national military and historical parks, is in charge of a local superintendent, who resides in the park and is responsible to the headquarters office in Washington for the administration of the area under his control.

The protective work is done by the ranger force, headed by a chief ranger, who reports to

Courtesy, National Park Service

KILAUEA VOLCANO, HAWAII NATIONAL PARK

By J. E. Haynes, St. Paul

JACKSON LAKE, GRAND TETON NATIONAL PARK

the superintendent. Park ranger duties include checking travel, directing traffic, enforcing the rules and regulations for the protection of the park, giving information to tourists, fire-fighting, improvement of trails, protection of wild animals, fish planting, supervision of campgrounds, and numerous other duties.

ACCOMMODATIONS FOR VISITORS

The supplying of adequate living accommodations for visitors is an important phase of national park development, especially in those parks handling from 100,000 to nearly half a million visitors annually. The National Park Service, in addition to providing roads and trails and the necessary buildings for carrying on the administration of the parks, also provides public automobile camps. The main camps in the larger parks have all the modern improvements, with water, electric light, and open fireplaces.

EDUCATIONAL USES

The national parks and national monuments offer exceptional opportunities for informal education. The education afforded in these areas is not the kind that is acquired in schools or from textbooks. Rather, the city dweller has an opportunity to acquire, under the leadership of ranger naturalists, information about trees and plants that all skilled woodsmen know almost as second nature. The person untrained in the sciences, seeing such a great work of nature as the Grand Canyon, is treated to a free course in popular geology when he inquires of the naturalist how the great gorge came into existence, how long it was in the making, and why the banded colorings. In the areas of historic significance, the main stress in the educational work is laid upon the particular story—colonial, military, or whatever it may be—that the reservation was established to tell. This

demand for knowledge is met primarily in two ways—through the ranger naturalist and historian service and through the museums. The ranger naturalists and historians are men and women trained in the natural sciences, history, or archeology and in public contacts. They conduct parties out on the park trails on short or long trips and give informal talks at the campfires in the public auto camps, in the lodge and hotel lobbies, and in the museums.

The museums in the wilderness national parks and monuments are designed primarily to interest the average visitor in finding out for himself just what the particular unit has to offer. It has been said that the museum exhibits are in reality only the index to the park or monument, which is the real museum.

In the historical areas the museums contain exhibits which portray the story of the area, as well as relics and artifacts connected with the human events which transpired in them, and which by their importance in the pageant of our national history entitle the areas to the status of historic shrine.

So in our prehistoric monuments. There the museum exhibits include implements in use a thousand years ago in grinding corn, and in other ordinary routine of life—a sandal or other bit of clothing or personal adornment; shreds of baskets; pottery of many designs and colors.

Visiting one of these prehistoric exhibits is an alluring introduction to the study of archeology—yet seemingly it is just getting a little first-hand information on how our neighbors of many centuries ago lived. And visitors find themselves quite as curious about their long-ago neighbors as about those who live next door today.

Courtesy, U. S. Dept. of the Interior

LONGS PEAK, ROCKY MOUNTAIN NATIONAL PARK

OUR NATIONAL PARK SYSTEM

The following tables give the name, year established, location, area in acres, and special characteristics of some of the areas in our National Park System.

NATIONAL PARKS

Acadia, 1919, Maine, 24,629 acres. Mostly on a sea-encircled island, with a bold promontory on nearby mainland.

Bryce Canyon, 1928, Utah, 35,980 acres. Box canyon filled with countless array of fantastically eroded pinnacles of vivid coloring.

Carlsbad Caverns, 1930, New Mexico, 49,568 acres. Series of connected caverns believed to be the largest in the world.

Crater Lake, 1902, Oregon, 160,334 acres. Vividly blue lake of exceptional depth and clearness in vast crater.

Glacier, 1910, Montana, 984,310 acres. Remarkable for its picturesquely modeled peaks, gigantic precipices, 250 lakes, 60 small glaciers.

Grand Canyon, 1919, Arizona, 645,120 acres. A highly colored, mile deep gorge. One of world's greatest spectacles.

Grand Teton, 1929, Wyoming, 96,000 acres. Most spectacular portion of the Teton Range.

Great Smoky Mountains, 1930, North Carolina and Tennessee, 460,030 acres. Includes the most massive mountain uplift in the East and the largest and finest virgin hardwood forest in the United States.

Hawaii, 1916, Hawaii, 173,399 acres. Large volcanoes, two active, including the periodic Kilauea Lake of Fire.

Hot Springs, 1921, Arkansas, 1,011 acres. Medicinal hot springs said to possess healing properties.

Isle Royale, 1940, Michigan, 133,839 acres. A roadless wilderness in Upper Lake Superior. Includes, in addition to 44-mile-long Isle Royale, a number of nearby islets.

Kings Canyon, 1940, California, 454,600 acres. Contains numerous High Sierra Peaks 12,000 to 14,000 feet high, also outstanding groves of giant Sequoias. The former General Grant National Park, with its two groves of Sequoias, is a detached section of this park.

Lassen Volcanic, 1916, California, 104,527 acres. Recently active volcano and interesting display of lava formations and hot springs.

Mammoth Cave, 1936, Kentucky, 49,954 acres. Series of caverns, including spectacular onyx cave formation.

Mesa Verde, 1906, Colorado, 51,334 acres. Contains most notable and best preserved prehistoric cliff dwellings in America.

Mount McKinley, 1917, Alaska, 1,939,493 acres. Highest mountain in North America, on whose slopes rise the largest northward-flowing glaciers of the Alaska Range.

Mount Rainier, 1899, Washington, 241,782 acres. Single-peak glacier system far exceeding in size and impressive beauty that of any other in the United States. Famous sub-alpine wildflower fields.

Olympic, 1938, Washington, 835,411 acres. Forests of unusual density, numerous glaciers, and summer feeding ground of rare Roosevelt elk.

Platt, 1906, Oklahoma, 912 acres. Sulphur and other springs said to possess healing properties.

Rocky Mountain, 1915, Colorado, 259,416 acres. Straddles Continental Divide at a point of supreme magnificence. Contains 65 named peaks with an altitude of over 10,000 feet.

Sequoia, 1890, California, 386,560 acres. Contains largest and probably oldest trees in the world (Sequoia gigantea) highest peak in continental United States; mighty canyons.

Shenandoah, 1935, Virginia, 193,441 acres. Embraces outstanding scenic section of the Blue Ridge Mountains.

Wind Cave, 1903, South Dakota, 12,640 acres. Limestone caves with boxwork formations. Herds of bison, wapiti and prong-horn antelope.

Yellowstone, 1872, Wyoming, Montana, and Idaho, 2,221,773 acres. Geysers and hot springs; wonderfully colored canyon; large wild bird and animal refuge.

Yosemite, 1890, California, 761,111 acres. Unique valley of unusual charm; spectacular waterfalls; granite wilderness of marvelous beauty.

Zion, 1919, Utah, 86,343 acres. Vividly colored and fantastically carved sandstone cliffs bordering a deep valley.

NATIONAL MONUMENTS

Ackia, 1938, Mississippi, 49 acres. Site of battle in May, 1736, in which the Chickasaws, aided by some Englishmen, repulsed a French force and their Choctaw Allies, thus preventing the French from obtaining complete control of the Mississippi Valley.

Andrew Johnson, 1942, Tennessee, 17 acres. Site of Andrew Johnson homestead and tailor shop in which he worked as a young man.

Appomattox Court House, 1940, Virginia, 970 acres. Scene of the surrender of the Confederate Army to the Federal Army on April 9, 1865.

Arches, 1929, Utah, 33,680 acres. Contains extraordinary examples of wind erosion in the form of gigantic arches, windows, and other unique formations.

Aztec Ruins, 1923, New Mexico, 26 acres. Has a prehistoric ruin of pueblo type containing 500 rooms; also other ruins.

Badlands, 1939, South Dakota, 150,103 acres. Spectacular exhibit of weathering and erosion.

Bandelier, 1916, New Mexico, 26,026 acres. Noted for its great number of cliff-dweller ruins of unusual ethnological and educational interest.

Big Hole Battlefield, 1910, Montana, 200 acres. Site of battlefield where in 1877 a small force of United States troops defeated a much larger force of Nez Perce Indians.

Black Canyon of the Gunnison, 1933, Colorado, 13,981 acres. Contains 10 miles of the deepest and most scenic portion of the Black Canyon.

Cabrillo, 1913, California, ½ acre. At this point in 1542 Juan Rodriquez Cabrillo, discoverer of California, first sighted land.

Canyon de Chelly, 1931, Arizona, 83,840 acres. Has many cliff dwellings in caves and crevasses.

Capitol Reef, 1937, Utah, 37,126 acres. Highly scenic area containing cliff dwellings, fossils, imprints of prehistoric animals, petrified trees, and unusual geologic formations.

Capulin Mountain, 1916, New Mexico, 680 acres. Principal feature a huge cinder cone of geologically recent formation.

Casa Grande, 1889, Arizona, 473 acres. Contains ruins that are noteworthy relics of a prehistoric age.

Castillo de San Marcos, 1924, Florida, 19 acres. Fort built by Spaniards in 1672. Formerly Fort Marion National Monument.

Castle Pinckney, 1924, South Carolina, 3½ acres. Part of the early defense of Charleston Harbor.

Cedar Breaks, 1933, Utah, 6,187 acres. Series of amphitheaters eroded to a depth of 2,000 feet. Spectacular canyons and cliffs of vivid coloring.

Chaco Canyon, 1907, New Mexico, 21,509 acres. Contains a large number of prehistoric communal dwellings.

Channel Islands, 1938, California, 1,120 acres. Includes parts of Anacapa and Santa Barbara Islands, which contain fossils of pleistocene elephants and noteworthy examples of ancient volcanism and marine life.

Chiricahua, 1924, Arizona, 10,695 acres. Unique natural rock formations.

Colorado, 1911, Colorado, 18,311 acres. Wonderful example of erosion, with lofty monoliths.

Craters of the Moon, 1924, Idaho, 48,184 acres. Fissure eruptions, volcanic cones, craters, lava flows, caves, and other volcanic phenomena.

Death Valley, 1933, California-Nevada, 1,907,720 acres. Fascinating desert region including the lowest point in the United States 279.80 feet below sea level.

Devil Postpile, 1911, California, 800 acres. Consists of peculiar hexagonal basaltic columns, like an immense pile of posts.

Devils Tower, 1906, Wyoming, 1,153 acres. Contains a remarkable natural rock tower of volcanic origin, 865 feet high.

Dinosaur, 1915, Utah-Colorado, 203,965 acres. Has the fossil remains of great prehistoric animals.

El Morro, 1906, New Mexico, 240 acres. Contains an enormous sandstone rock eroded in the form of a castle upon which inscriptions were carved by the early Spanish explorers; also cliff-dweller ruins.

Father Millet Cross, 1925, New York. Site for erection of cross to commemorate a cross erected by Father Millet on Good Friday, 1688, on what is now the Fort Niagara Military Reservation.

Fort Jefferson, 1935, Florida, 87 acres. Fortification built in 1846 to command and hold fine harbor in Tortugas Keys; unusual marine display in crystal water surrounding it.

Fort Laramie, 1938, Wyoming, 214 acres. Historic outpost for fur traders and miners on the Oregon Trail during California gold rush days.

Fort Matanzas, 1924, Florida, 18 acres. Old Spanish fort, grim reminder of massacres occurring when Spain contested for possession of Florida.

Fort McHenry, 1939, Maryland, 48 acres. An important United States military post during the War of 1812. Its successful defense against a British attack, September 13-14, 1814, inspired Francis Scott Key to write the "Star Spangled Banner."

Fort Pulaski, 1924, Georgia, 5,427 acres. Begun in 1829, completed in 1847, to replace Fort Greene of the Revolution.

Fossil Cycad, 1922, South Dakota, 320 acres. Has deposits of interesting plant fossils.

George Washington Birthplace, 1930, Virginia, 394 acres. The birthplace of George Washington where upon the old foundations the house has been reproduced as far as possible.

Gila Cliff Dwellings, 1907, New Mexico, 160 acres. Well preserved cliff dwellings.

Glacier Bay, 1925, Alaska, 2,299,520 acres. Contains great tidewater glaciers.

Gran Quivira, 1909, New Mexico, 611 acres. One of the earliest Spanish mission ruins in the Southwest; also Pueblo ruins.

Grand Canyon, 1932, Arizona, 201,291 acres. Adjoins the Grand Canyon National Park; provides new views of the famous Grand Canyon.

Great Sand Dunes, 1932, Colorado, 46,034 acres. Contains sand dunes which are among the largest and highest of any in the United States.

Holy Cross, 1929, Colorado, 1,392 acres. Two crevices on side of Mount of the Holy Cross, which when filled with snow form the shape of a cross.

Homestead, 1939, Nebraska, 161 acres. Site of first homestead in United States entered under the General Homestead Act of 1862, which opened the West to free settlement.

Hovenweep, 1923, Utah and Colorado, 286 acres. Prehistoric towers, pueblos and cliff dwellings.

Jackson Hole, 1943, Wyoming, 221,610 acres. Scene of two significant movements in the Nation's history, the fur trade and frontier settlement. With adjoining Grand Teton National Park forms one of the most complete biologic units in the National Park System.

Jewel Cave, 1908, South Dakota, 1,275 acres. Cavern of limestone formation. Consists of a series of chambers, connected by narrow passages, with numerous side galleries.

Joshua Tree, 1936, California, 837,480 acres. Notable example of basin and range physiography. Contains rare varieties of desert flora, among them the Joshua tree.

Katmai, 1918, Alaska, 2,697,590 acres. Dying volcanic region; includes the Valley of Ten Thousand Smokes.

Lava Beds, 1925, California, 45,967 acres. Unusual exhibits of volcanic action and lava flows in the shape of peculiar lava caves and tunnels.

Lehman Caves, 1922, Nevada, 640 acres. Caves of light-gray and white limestone, honey-combed by tunnels and galleries of stalactite formations.

Meriwether Lewis, 1925, Tennessee, 300 acres. Contains grave of Captain Lewis of the Lewis and Clark Expedition.

Montezuma Castle, 1906, Arizona, 521 acres. Contains a prehistoric cliff-dweller ruin of unusual size.

Mound City Group, 1923, Ohio, 57 acres. Famous group of prehistoric mounds.

Muir Woods, 1908, California, 425 acres. Notable for its great grove of redwood trees.

Natural Bridges, 1908, Utah, 2,740 acres. Has three natural bridges, the largest being 223 feet high and 65 feet thick at the top of the arch.

Navajo, 1909, Arizona, 360 acres. Has numerous cliff-dweller ruins in a good state of preservation.

Ocmulgee, 1936, Georgia, 684 acres. Contains Indian mounds unique in the Southeast.

Old Kasaan, 1916, Alaska, 38 acres. Abandoned Haida Indian village in which remain totem poles, grave houses, and monuments.

Oregon Caves, 1909, Oregon, 480 acres. Caves in limestone formation of great variety and beauty.

Organ Pipe Cactus, 1937, Arizona, 330,687 acres. Unusually fine example of Organ Pipe Cactus.

Perry's Victory and International Peace Memorial, 1936, Ohio, 14 acres. Commemorates Perry's victory over the British Fleet on Lake Erie.

Petrified Forest, 1906, Arizona, 93,199 acres. Abundance of petrified coniferous trees, one of which forms a natural bridge.

Pinnacles, 1908, California, 14,498 acres. Has many spire-like rock formations 600 to 1,000 feet high, also numerous caves.

Pipe Spring, 1923, Arizona, 40 acres. Contains an old stone fort, connected with early Mormon history, and a spring of pure water, most important to the early pioneers in the desert region.

Pipestone, 1937, Minnesota, 115 acres. Notable for its quarry from which Indians obtained material for making peace pipes.

Rainbow Bridge, 1910, Utah, 160 acres. A unique natural bridge in the shape of a rainbow. This bridge, very symmetrical in form, rises 300 feet above the water.

Saguaro, 1933, Arizona, 63,284 acres. Contains many giant cacti of unusual scientific interest.

Santa Rosa Island, 1939, Florida, 9,500 acres. A 44-mile-long barrier reef of clear white sand; has outstanding recreational, historical and scientific values.

Scotts Bluff, 1919, Nebraska, 3,476 acres. A region of historic and scientific interest. Many famous old trails traversed by the early pioneers passed this way.

Shoshone Cavern, 1909, Wyoming, 212 acres. A cave of considerable extent decorated with incrustations of crystals.

Sitka, 1910, Alaska, 57 acres. Contains 18 totem poles of the best native workmanship; is of historic interest in the history of the Russians and early Indians.

Statue of Liberty, 1924, New York Harbor, 10 acres. Site of Statue of Liberty.

Sunset Crater, 1930, Arizona, 3,040 acres. A volcanic crater with lava flows and ice caves.

Timpanogos Cave, 1922, Utah, 250 acres. Limestone cavern almost 600 feet in length.

Tonto, 1907, Arizona, 1,120 acres. Two cliff-dweller ruins consisting of 2 and 3 storied walls of adobe with the supporting beams and lintels of windows and low doors still in place.

Tumacacori, 1908, Arizona, 10 acres. Contains a ruined Spanish mission dated back to the seventeenth century.

Tuzigoot, 1939, Arizona, 43 acres. Contains ruins of several units of an ancient pueblo occupied over several centuries by a varying population from the North, South, and West.

Verendrye, 1917, North Dakota, 253 acres. Includes Crowhigh Butte, from which explorer Verendrye first beheld land beyond the Missouri River.

Walnut Canyon, 1915, Arizona, 1,879 acres. Contains cliff dwellings built under the outward sloping canyon walls.

Wheeler, 1908, Colorado, 300 acres. Unusual combination of fantastic pinnacles and interesting gorges.

White Sands, 1933, New Mexico, 144,947 acres. An area of glistening deposits of wind-blown gypsum almost crystal clear; interesting plant and animal life.

Whitman, 1940, Washington, 46 acres. Site of Indian mission and school established in 1836 by Dr. and Mrs. Marcus Whitman.

Wupatki, 1924, Arizona, 35,813 acres. Contains prehistoric dwellings of the ancestors of the Hopi Indians.

Yucca House, 1919, Colorado, 10 acres. Has great mounds containing prehistoric ruins.

Zion, 1937, Utah, 49,150 acres. Contains the Hurricane Cliffs, caused by a 3,000-foot displacement along the fault of the same name; also Kolob Canyon.

NATIONAL PARKWAYS

Blue Ridge, 1936, Virginia, North Carolina, 34,296 acres. A scenic parkway averaging 2,500 feet in elevation, following the Blue Ridge Mountains and embracing several scenic and recreational areas.

George Washington Memorial, 1930, Virginia, District of Columbia and Maryland, 2,367 acres. Embraces many interesting landmarks associated with the life of George Washington. Includes Mt. Vernon Memorial Highway between the National Capitol and Mt. Vernon.

Natchez Trace, 1934, Mississippi, Alabama and Tennessee, 12,834 acres. A parkway following the general location of the old Indian trail between Nashville and Natchez, known as the "Natchez Trace," an important route in early travel.

E.K.HARPER